Saskatchewan
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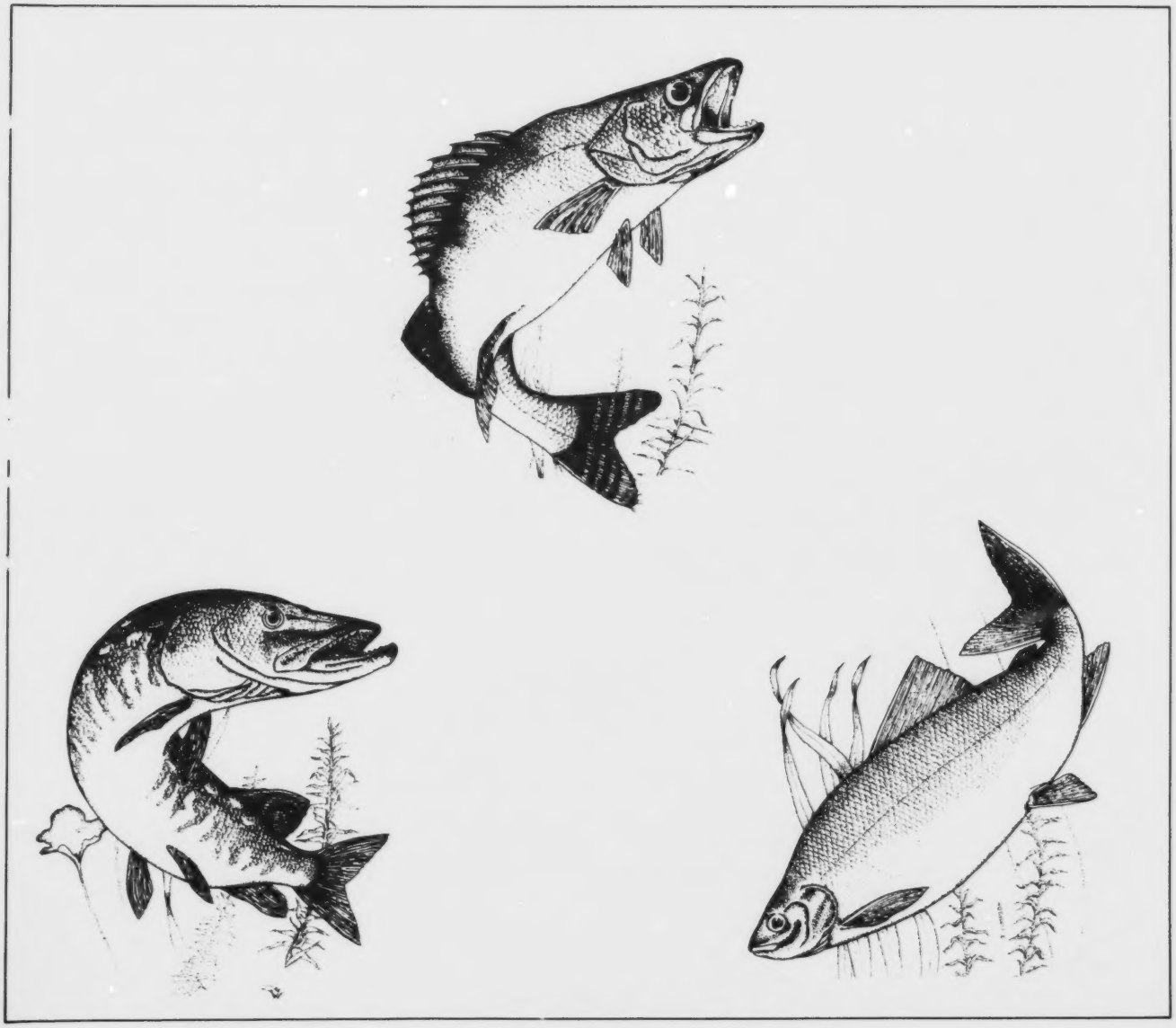
Fisheries Branch

Biological Survey of Montreal Lake, 1987

Technical Report 88-4



BIOLOGICAL SURVEY OF MONTREAL LAKE, 1987

by

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FISHERIES TECHNICAL REPORT 88-4

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EXECUTIVE SUMMARY

Situation

A comprehensive fisheries investigation was carried out on Montreal Lake during the summer of 1987. Its purposes were to examine the fishery resource and aquatic habitat of the lake and to assess the current status of the economically important fish stocks.

Results

Montreal Lake is situated on boreal glacial deposits approximately 100 km north of Prince Albert. It has an area of 452.3 km^2 and a volume of 1277 $\times$ $10^6 m^3$. Mean and maximum depths are 2.2 m and 8.5 m respectively. Outflow is into the Churchill River System via the Montreal River, Bigstone Lake and Lac la Ronge. The shallow depth, large expanse of open water and scarcity of islands provide for complete mixing of the lake during the summer months. As a result, little differences in temperature and dissolved oxygen occur between surface and bottom waters.

Water quality in Montreal Lake is typical of lakes located in the forest zone, with total dissolved solids ranging from 166 - 185 mg/L and total alkalinity about 156 mg/L. No significant changes in major ions appear to have

occurred in the last 30 yr. Reduction in Secchi disc transparency, and a change in dominant phytoplankton from diatoms to blue-green algae in the last 3 decades suggest increased nutrient loading.

In terms of benthic standing crop, Montreal Lake is generally unproductive compared to other lakes in Saskatchewan. Standing crop of benthic fauna was 17.3 kg/ha in 1987. Total number of organisms collected was 1366/m^2, a slight increase since 1955 when 1102/m^2 were collected. Midge larvae were the dominant benthic organism, followed by sphaeriid clams, freshwater shrimp, snails and sludge worms in decreasing order of significance.

Fifteen species of fish were collected in Montreal Lake during the study. Yellow perch were collected most frequently in the seine hauls, followed by juvenile white suckers, spottail shiners, ninespine sticklebacks and fathead minnows. Several species of minnows collected were not reported in a preliminary survey carried out in 1955.

White suckers were the dominant species captured in the gillnets, comprising 30.5% by number and 44.7% by weight. Ciscoes made up 28.4% by number and 3.5% by weight of the standard gang gillnet catch. Other large species abundant in the gillnets were walleye (19.8%), pike (15.8%), perch (5.5%) and whitefish (3.3%). An average of 250 fish

per standard gang were captured during the summer months of 1987, 55 fish fewer than the average per net set in 1955.

Walleye is currently the dominant gamefish in Montreal Lake. Relative numbers have increased since 1955 when walleye comprised 10% of the gillnet catch. The majority of walleye captured in 1987 were between 38 and 48 cm in length. Ages of walleye ranged from 2 to 10 yr, with a majority falling in the 5 yr class. Age at sexual maturity is 4 yr for males and 5 yr for females. Juvenile walleye were captured in almost 40% of the seine hauls and were mainly caught along the eastern shores of Montreal Lake. The presence of numerous age classes, particularly older age classes, and relatively old age at sexual maturity suggest that walleye stocks in Montreal Lake are not being heavily exploited.

Relative numbers of pike have increased since 1955 when they comprised 5% of the total gillnet catch. The majority of pike collected in the 1987 gillnets were between 42 and 62 cm in length and were 3 to 6 yr in age. Only 2 juvenile pike were captured by seining. Although pike are now abundant in Montreal Lake, the lack of young age-classes suggests that future pike populations may not be as strong as they are now.

Results of test-nettings indicate that there has been little change in the abundance of whitefish in Montreal

Lake since 1955 when they comprised about 0.5% of the total catch. The majority of whitefish caught in 1987 were between 38 and 47 cm in length and were 3 to 7 yr old. No juvenile whitefish were captured by seining. Age at sexual maturity for both sexes occurs at 3-4 yr. The whitefish population in Montreal Lake, although small, does not appear to be overexploited. The large sucker population is probably competing with the whitefish for food resources.

Montreal Lake is subjected to commercial, sport and domestic fishing. Fishing records, available since 1925, show that the commercial harvest has been characterized by large year-to-year fluctuations. These fluctuations are probably caused by varying fishing effort rather than changes in the fish stocks in the lake. Number of licences issued annually has ranged from 2 to 68. Currently the commercial fishing quota is set at 90 700 kg, including 56 700 kg whitefish, 23 000 kg walleye and 11 000 kg pike. The legal mesh size has remained at 12.7 cm. Average annual production is 1.18 kg/ha, comprising 75.5% whitefish, 12.0% walleye, 5.8% pike and 6.7% other species. Since 1980, the harvest of whitefish has decreased and harvests of gamefish, particularly walleye, have increased. In 1987-88, 19 commercial fishing licenses were issued for a total commercial harvest of 34 717 kg of fish of which 31 271 kg were delivered to the Freshwater Fish Marketing

Corporation and 3 832 kg were sold locally. Infestation of whitefish with *Triaenophorus* cysts and the resulting poor price of the cutter quality fish have probably contributed to increased harvests of gamefish by the commercial fishery.

Sport fishing on Montreal Lake is currently unquantified. Angling during the summer months is reportedly light, but a substantial ice fishery occurs during the winter months.

Ten domestic fishing licenses and 12 Indian fishing permits were issued in 1987-88. Officers reported a domestic harvest of 650 kg of fish. Based on total dissolved solids content, standing crop of bottom fauna, mean depth and lake area, the potential sustained yield of fish in Montreal Lake is estimated to be 6.32 kg/ha/yr. Sustained yields for the three highly valued species are walleye: 1.57 kg/ha/yr (69 821 kg); pike: 1.37 kg/ha/yr (60 927 kg); and whitefish 0.33 kg/ha/yr (14 678 kg). A comparison of actual fish harvest with potential sustained yield indicates that Montreal Lake is very lightly fished. Based on the findings of the study, the following recommendations are suggested:

1. The legal mesh size should remain at 12.7 cm. With the use of this mesh size, the commercial fishery is not harvesting immature fish.

2. The annual commercial fishery quota should remain at 90 700 kg. Separate quotas for the three economically important species are necessary. The quotas for walleye and pike should be increased to 30 000 and 17 000 kg, respectively using estimates of the sustained yield as a guideline: walleye, 1.8 kg/ha; pike, 1.4 kg/ha; whitefish, 0.33 kg/ha. Thereby the whitefish quota would be reduced to 43 700 kg.

3. The above allocation provides for 54 726 kg of highly valued species for the sport, domestic and Indian fisheries.

4. Sport and food fish survey should be conducted regularly to obtain information on angler and domestic harvests during both the summer and winter seasons.

5. The fish populations in Montreal Lake should be reassessed in 5 yr relative to changes in quotas and fishing pressure.

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1. INTRODUCTION

Montreal Lake, situated in the geographic center of Saskatchewan, was the subject of a limnological and fisheries investigation from May 26 to August 27, 1987. The study was carried out by the Saskatchewan Fisheries Laboratory, Fisheries Branch, Saskatchewan Parks, Recreation and Culture. An earlier study in 1955 emphasizing limnological characteristics of four lakes, including Montreal Lake provided some comparative baseline data for the present study.

A commercial fishery on Montreal Lake is substantiated by records dating back to 1925. Since 1981, the commercial quota has been set at 90 700 kg as a summer limit. Species taken consist of whitefish, pike and walleye. A summer and winter sport fishery exists on the lake, but at present is unquantified. No outfitting camps, campgrounds or proper boat launching facilities currently exist on the lake. Development of an outfitting camp has been proposed for the near future.

In anticipation of changes in fish management strategies as a result of increased demands on the fishery, a baseline study was carried out on Montreal Lake.

Objectives of the study were to produce a bathymetric map, to obtain data on the physico-chemical characteristics, and to carry out a biological survey of the net-plankton, bottom fauna and fishes of the lake. Information gathered was used to estimate potential productivity and sustained yields, develop and implement fishery utilization programs, and provide background information.

2. DESCRIPTION OF STUDY AREA

Montreal Lake (52°20' 105°40') is situated in central Saskatchewan approximately 100 km north of Prince Albert (Fig. 1). The lake lies on cretaceous glacial deposits in the Northern Coniferous section of the boreal forest (Mendis 1956). Montreal Lake is accessible at its south and north ends from Highway 969, and on its west side off Highway 2 at Weyakwin. Three communities are situated nearby: Molanosa, Weyakwin, and Montreal Lake. Montreal Lake Indian Reserve (I.R.#106) is located at the south end of the lake.

Several rivers and streams originating in the Prince Albert National Park provide the main discharge into Montreal Lake. These include Waskesiu River, MacLennan River and Crean River. The Weyakwin and Bittern Rivers flow into the northern and southern areas, respectively, of Montreal Lake. Skunk Creek, Steep Creek and Birch Creek provide

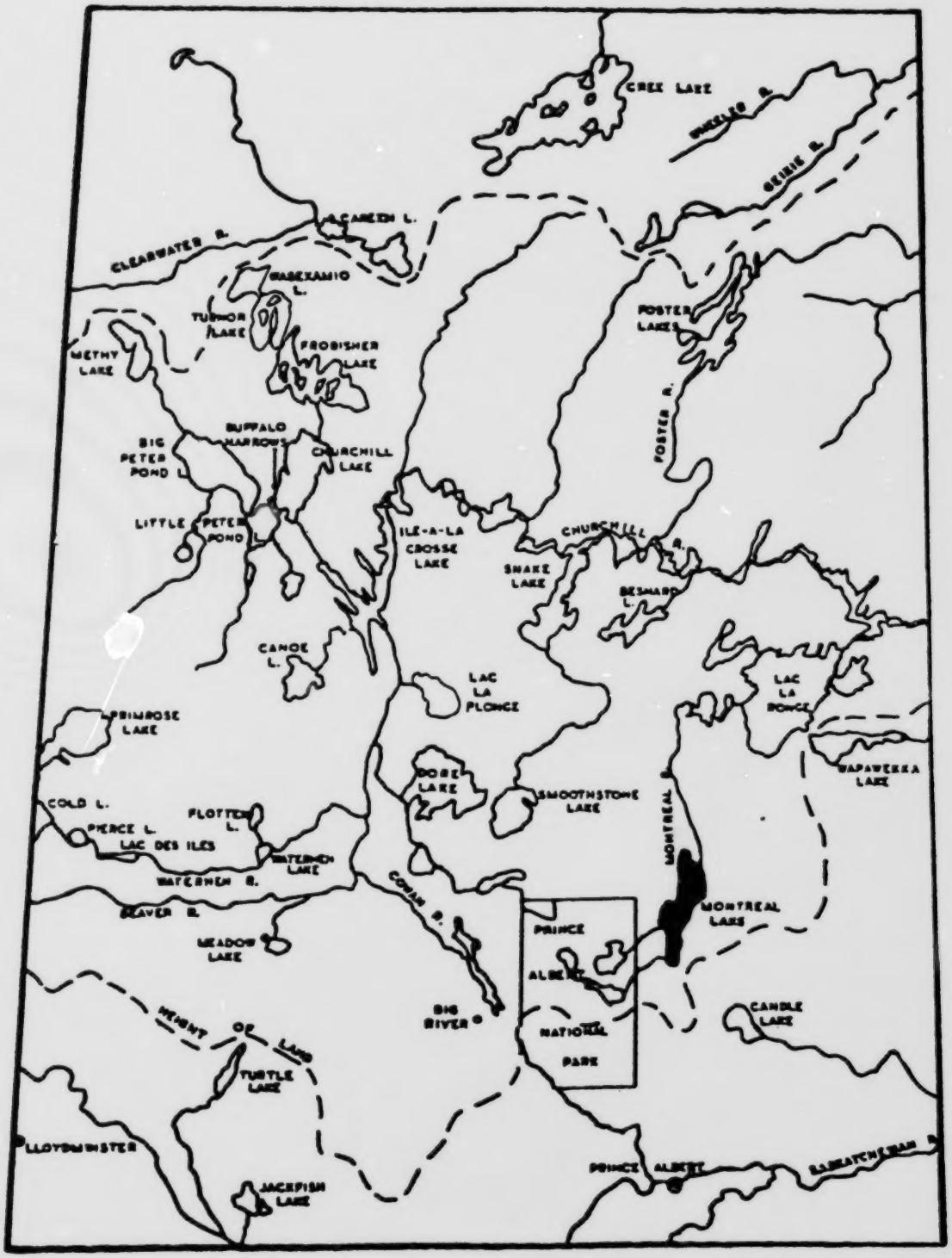

Fig. 1 Map showing the location of Montreal Lake.

local drainage from the east side. The total drainage area for Montreal Lake is approximately 700 km² (Mendis 1956). Montreal Lake empties into the Churchill River system by way of the Montreal River, Bigstone Lake and Lac la Ronge.

A small rock weir remains in the Montreal River near the outlet of Montreal Lake. It was built in 1948 and raised water levels by about 15 cm to provide improved habitat for muskrats. The weir was upgraded in 1955.

The major axis of Montreal Lake lies in the north-south direction. The lake is comparatively large, with a surface area of 452.3 km². A total of 21 islands occur in the lake, but only Ferguson Island, with an area of 7.0 km², is of any significant size. As a result, little protection from windy conditions is provided by the islands. The lake is naturally divided into a northern and a southern basin by Ferguson Island.

3. METHODOLOGY

Field work began on May 26, 1987 and was concluded on August 27, 1987. During June and July, the study alternated between 10 days in the field and 4 days out. Early termination of summer assistants curtailed field investigations in the first week of August.

Depth soundings were obtained with a Furuno FG Mark 3 echo sounder. Sounding transects were marked on

work maps prepared from 1:50 000 topographic maps. The area in each depth zone was measured from the work map, using a digital planimeter (Numonico Corp., Model 1250-1). A total water area and volume were then calculated.

Limnological conditions were monitored at two stations during the study on a biweekly basis from May 26 to July 21, and a final measurement on August 25. Station A was located in the northern basin (See Fig. 2). Station B, in the southern basin, is approximately at the same location as Station I in the earlier survey (Mendis 1956). Limnological measurements consisted of temperature, dissolved oxygen, and pH of the water.

Air and surface water temperatures were measured with a rod thermometer. Water temperature and dissolved oxygen profiles were obtained with a YSI temperature-dissolved oxygen meter. Surface and bottom water pH were determined colorimetrically with a Hellige pocket comparator. Transparency was measured with a Secchi disc, 20 cm in diameter.

Water samples were collected from the surface, and from the bottom using a Kemmerer water sampler, and stored in 2-L plastic bottles for chemical analyses. Composite water samples made up of surface and bottom samples from

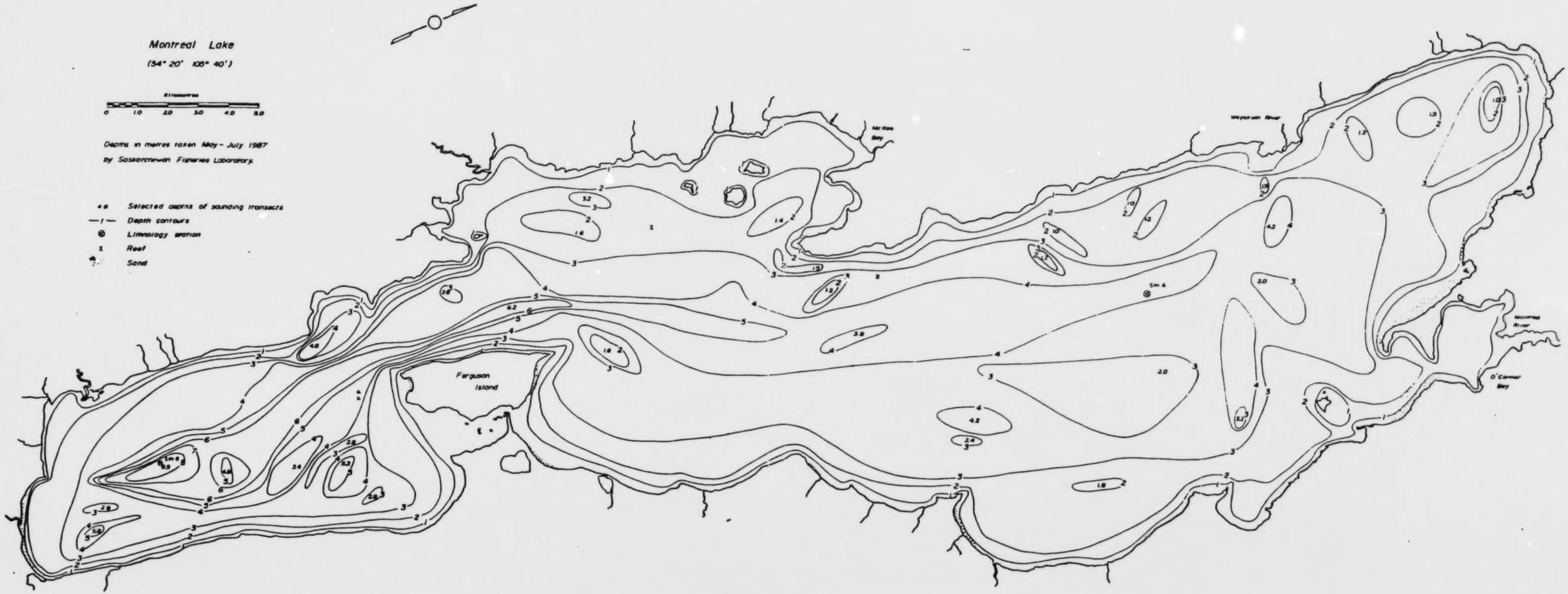

Fig. 2 Bathymetric map of Montreal Lake.

station B for each month, were sent to the Provincial Lab. in Regina for mineral analyses. Total dissolved solids were measured by evaporating 100 ml of water to dryness at 110°C (APHA 1971). Similar samples for chlorophyll a analysis were filtered immediately upon collection, using Gelman Type A-E glass fibre filters and a hand operated vacuum pump. The filters were labelled and refrigerated. Extraction of chlorophyll a was done in the laboratory, using acetone. Values were measured using a spectrophotometer (Bausch and Lomb Spectronic 88), following the method of Lorenzen (1967).

Water samples for qualitative identification and enumeration of plankton were collected using a 16 m length of 1.27 cm (I.D.) Tygon ™ tube, as described by Tonolli (1971). The tube was lowered from the water surface to the lake bottom, providing a sample of the entire water column. This method has the advantage of collecting nanno- and ultra-plankton, which are lost from vertical hauls taken with a Wisconsin plankton net. The water samples obtained with the Tygon tube were preserved using 'Lugol's' solution, made up of 10 g pure iodine, 20 g KI, 200 mL distilled water and 20 g glacial acetic acid (Vollenweider 1974). This fixative shows flagella and cilia well, a necessity when identifying organisms to the genus and species level.

Identification and counts were made on 1 ml aliquots, using an inverted microscope.

Total vertical hauls were taken with a large Wisconsin net of No. 20 bolting silk (70 meshes/cm) to estimate total plankton biomass. Samples were taken at each visit to the limnology station and were preserved in 5% formalin. Quantitative analyses consisted of drying the samples at 52°C, weighing, and then ashing at 600°C to obtain dry weight and percentage of mineral matter. Average net efficiency was determined to be 34.3% by filtering known quantities of water through the net.

A 22.9 cm Ekman dredge was used to collect lake bottom fauna. Grab samples were washed through a series of 3 screens, the finest having 11 meshes/cm providing a pore size of 0.65 mm. Organisms retained by the screens were preserved in 70% alcohol for identification, enumeration and weighing in the laboratory. Molluscs were weighed separately and one-third of their weight was deducted as shell weight. Dry weight was assumed to be 12% or 15% of wet weight, depending on whether chironomids or amphipods were dominant.

Large fish species were sampled by setting half standard gangs of gillnet (22.8 m each of 3.8-, 5.1-, 7.6-, 10.2-, 12.7- and 14.0- cm stretched mesh) in the lake. The standard gang (276 m in length) has been adopted as a

standard measure for evaluating fish populations in Saskatchewan, and allows data collected from different water bodies to be compared. The nets were left for 24 hr, and then lifted. Sport and commercial fish species were enumerated, measured (fork length) and weighed; sex and state of maturity were noted, and stomach contents were examined. Scales, otoliths, fin rays and cleithra were collected from fish of economic importance for age determination. Usually two ageing media were taken from each fish. Techniques used are described by Musker (1985). Rough fish species (suckers, ciscoes, burbot and perch) were enumerated. Maximum and minimum lengths and total weights were recorded. Individual lengths and weights were taken from a representative sample.

Minnows and juveniles of larger species of fish were sampled by seining along the shores and islands of Montreal Lake. Samples were preserved in 5% formalin for later identification and enumeration in the laboratory. Juveniles of gamefish species were measured and weighed, and their stomach contents were examined.

4. RESULTS

4.1 MORPHOMETRIC AND PHYSICO-CHEMICAL FEATURES

4.1.1 Morphometric Features

Montreal Lake is a relatively large lake, with a total area of 452.3 km^2 (Table 1). It is 51.5 km long, and 10 km wide as determined from topographic maps. Its main axis lies in a north-south plane. Although there are 21 islands in the lake, only two have areas greater than 0.1 km^2: Spruce Island has an area of 0.12 km^2 and Ferguson Island has an area of 6.96 km^2. Total island area is 7.58 km^2

Montreal Lake is comparatively shallow, with a maximum depth of 8.5 m and a mean depth of 2.2 m. Almost 95% of the lake area is shallower than 5 m. This is substantially shallower than the mean depth of 4.9 m determined by Mendis (1956). During the earlier study, the southern basin and only a small portion of the northern part of the lake were measured by handline. The unsounded northern portion was assumed to be similar in depth and to have the depth strata in the same proportions as the sounded part. Soundings taken during the 1987 study indicate that the northern portion of the lake is much more shallow than the southern basin (Fig. 2). Mendis appears to have

Table 1. Morphometric features of Montreal Lake, 1987.

Depth zones, m	Area km^2	Area %	Lake volume x $10^3 m^3$
0-1	33.48	7.5	427 979
1-2	65.38	14.6	378 547
2-3	124.76	28.1	283 473
3-4	181.04	40.7	130 572
4-5	17.80	4.0	31 153
5-6	10.92	2.5	16 793
6-7	9.17	2.1	6 748
7-8	1.34	0.3	1 492
>8	0.82	0.2	205
Total			1 276 961
Water area	444.72		
Island area	7.58		
Lake area	452.30		

Mean depth, m	2.2
Maximum depth, m	8.5
Shoreline length, km:	
excluding islands	176.4
including islands	200.2
Shore development:	
excluding islands	2.4
including islands	2.7

overestimated the deep areas of the lake and thus the mean depth.

Shore development (the ratio of the length of the shoreline to the length of the circumference of a circle of area equal to that of the lake), including islands, was 2.7. This value reflects the long narrow characteristic of the lake and defines the potential for development of littoral communities in proportion to the volume (Wetzel 1975).

4.1.2 Temperature

Breakup on Montreal Lake occurs approximately May 15. The open water period extends to about mid November. The water warms rapidly because of the high surface area to volume ratio.

At station A, in the north basin of Montreal Lake, surface water temperatures varied from 14.0°C on June 9 and August 25 to a maximum of 19.0°C on June 23 (Appendix 1). At station B, surface temperatures ranged from 11.0°C on May 28 to a high of 20.0°C on July 7 (Appendix 2). Variations in temperature between the two stations are due to differences in dates and times of measurement.

Bottom temperatures varied from 8.0°C at station B on May 28 to 18.5°C at station A on June 23. At both stations, bottom temperatures increased up until June 23 and then decreased. Little difference between surface and

bottom water temperatures occurred (Fig. 3). The large expanse of open shallow water and scarcity of islands result in a high degree of mixing of the water mass. Similar results were noted by Mendis (1956) during the earlier survey.

4.1.3 Dissolved Oxygen

Dissolved oxygen concentrations varied from a high of 12.0 mg/L (110% saturation) at station A on May 26 to a low of 2.6 mg/L (28% saturation) at bottom strata of station B on June 23. Measurements taken at station A were always at or near saturation at every depth. Surface waters at station B were at or near saturation. Bottom waters at Station B were generally 60% saturated or more with the exception of the reading taken on June 23. Dissolved oxygen levels at both stations decreased during the summer months and then increased, showing a characteristic inverse relationship to changes in water temperature (Fig. 3).

4.1.4 pH and Transparency

The pH of Montreal Lake varied between 8.0 and 8.4. These values are similar to the range of 7.8 to 8.2 determined by Mendis (1956). As in the earlier study,

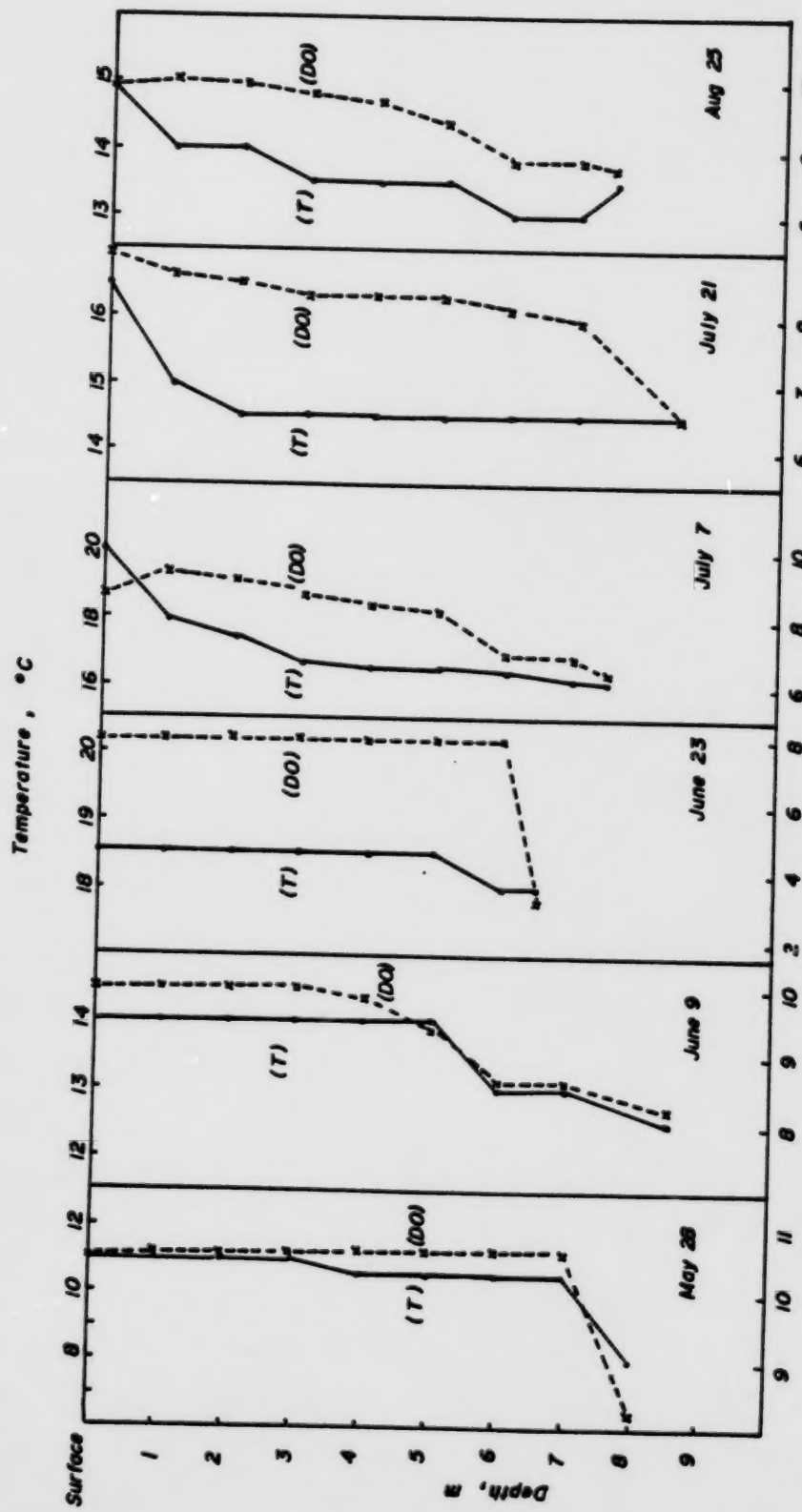

Fig. 3 Oxygen (DO) and temperature (T) profiles at station B, Montreal Lake, 1987.

little difference occurred in the pH between surface and bottom waters.

Secchi disc transparency ranged from 0.8 m to 1.3 m. Average values were 0.9 m for station A, and 1.0 m for station B. No consistent trend in transparency measurements during the summer months was evident. Mendis (1956) determined the average Secchi disc transparency to be 1.7 m during 1955 (Fig. 4), which is substantially greater than average values measured in 1987. The greater transparency in the earlier study suggests less turbidity.

4.1.5 Water Quality

Results of water analyses on four composite water samples collected from station B on Montreal Lake are given in Table 2. A few parameters were measured in 1955 (Mendis 1956) and in 1940 (Rawson and Moore 1944). These are included for comparison.

Total dissolved solids by evaporation ranged from 166 - 185 mg/L during the summer of 1987. Concentrations measured in 1940 and 1955 by evaporation at 180°C were comparable, at 166 and 229 mg/L respectively. With total dissolved solids ranging between 100 - 200 mg/L, Montreal Lake is typical of lakes in the forest zone as described by Liaw and Atton (1981). Lakes in the forest zone usually

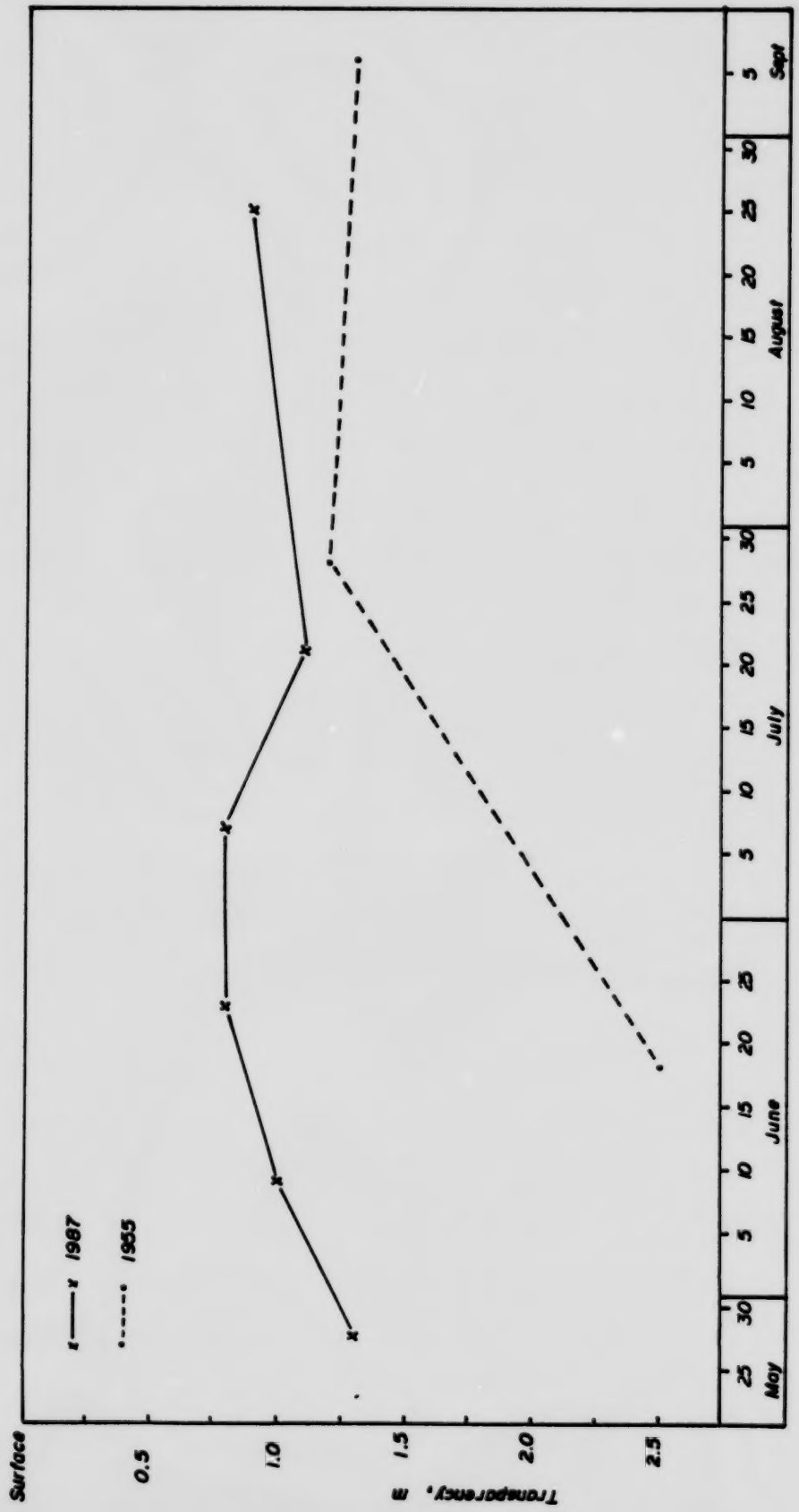

Fig. 4 Water transparency as measured by Secchi disc in Montreal Lake, 1955 and 1987.

Table 2. Chemical analyses of water from Montreal Lake, 1940, 1955 and 1987. All values except pH are given in mg/L.

	1940*	1955+	1987			
	July	July 28	May 28	June 23	July 21	Aug. 25
Total dissolved solids @ 110°C	166	229	174	185	166	167
Total dissolved solids, calc.			252	252	246	242
Loss on ignition @ 550°C			51	84	83	73
Bicarbonate ($HCO_3^=$)		186	193	193	190	185
Chloride (Cl^-)			<2	<2	<2	<2
Sulphate ($SO_4^=$)		11	<10	<10	<10	<10
Calcium (Ca^{++})		41	38	42	35	45
Magnesium (Mg^{++})		20	16	13	16	9
Sodium (Na^+)			5	4	5	3
Nitrate ($NO_3^=$)			<1	<1	<1	<1
Total alkalinity (as $CaCo_3$)			158	158	156	152
Total hardness (as $CaCo_3$)			160	156	152	148
Iron			<0.1	0.1	<0.1	<0.1
Manganese			<0.01	0.04	<0.01	<0.01
pH			8.2	8.2	8.2	8.2

*Rawson and Moore 1944

+Mendis 1956

have alkalinities ranging between 11 - 237 mg/L (Liaw and Atton 1981): Montreal Lake with an average total alkalinity of 156 mg/l during the summer of 1987 is well within this range.

As indicated in Table 2, concentrations of calcium, magnesium, sodium and bicarbonate did not vary substantially over the summer months during 1987. Several parameters (sulphate, nitrate, iron and manganese) were below the detection limits of the analytical method. Measurements of bicarbonate, calcium and magnesium were similar in 1955 and in 1987 suggesting little change in water quality in the past 30 years. Values are typical of lakes located in the forest zone, reflecting their geology and drainage (Liaw and Atton 1981).

4.2 PLANKTON

Identification and enumeration of phytoplankton were carried out for samples collected during each of the summer months at stations A and B in Montreal Lake. Numbers of organisms (no. cells x 1000/L) ranged from 26.7 at station B on May 28 to 116.8 at Station B on August 25 (Appendix 3). Greatest concentrations of plankters occurred in June at station A (82.3 cells x 1000/L), and in late August at station B (Fig. 5). Variation in numbers of

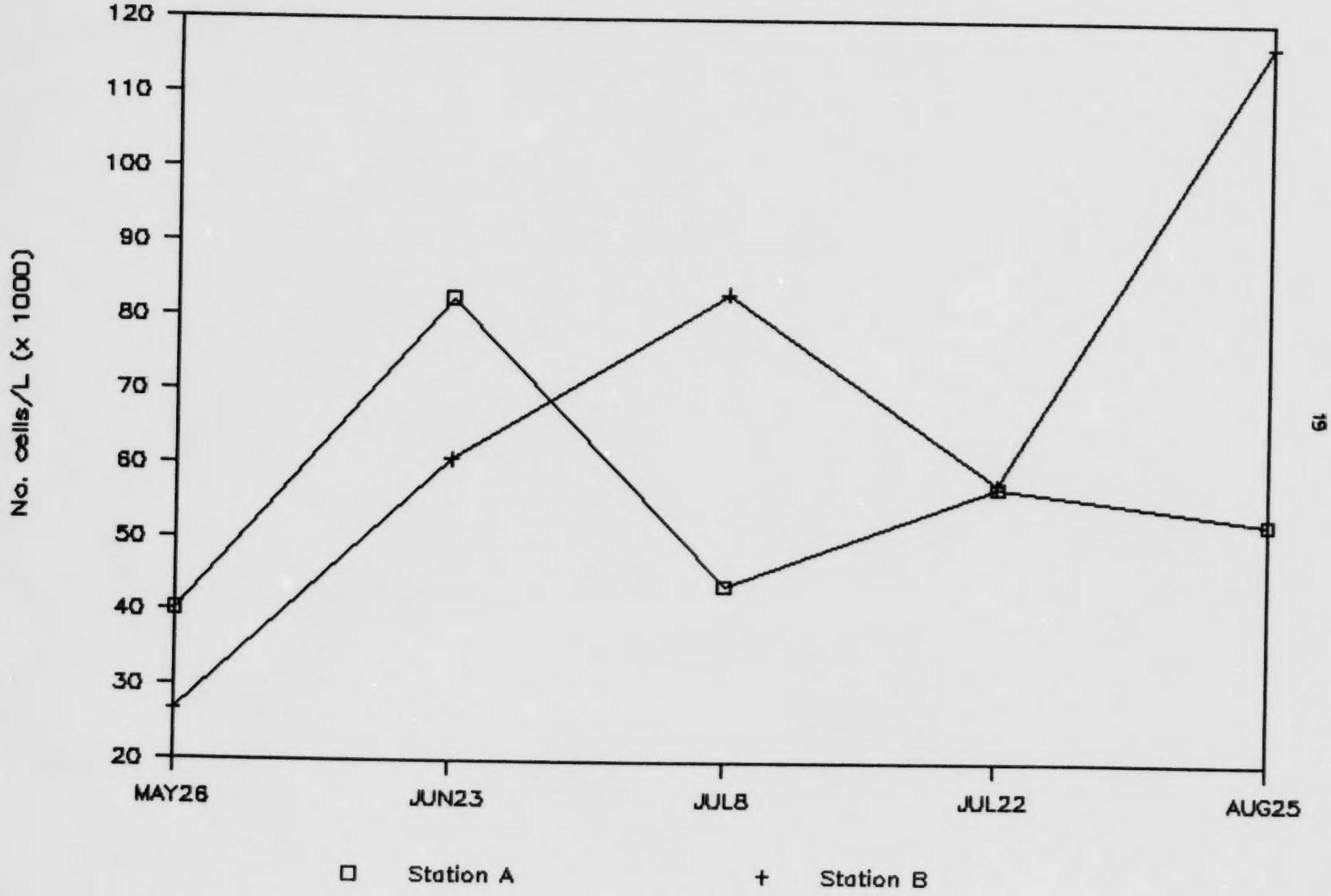

Fig. 5 Changes in phytoplankton abundance at stations A and B, Montreal Lake, 1987.

cells/L between the two stations on the same date may be due to differences in time of sampling or minor differences in habitat. Station A was generally sampled in mid-morning whereas samples from station B were collected in mid-afternoon.

Analyses of the phytoplankton collected from Montreal Lake in 1987 indicated that blue-green algae were dominant throughout the entire summer (Fig. 6) at both stations. This is in contrast to results obtained in 1955 (Mendis 1956) when diatoms were the dominant form from spring through summer. In 1987, green algae were ranked second in abundance, followed by diatoms. Golden algae, euglenoids and dinoflagellates contributed only a small proportion of the phytoplankton.

Microcystis aeruginosa was the dominant blue-green species, making up more than 50% of the total number of Myxophyceae. Other abundant blue-greens found in Montreal Lake consisted of *Coelosphaerium*, *Anabaena* and *Aphanocapsa*. *Fragilaria crotonensis* was the most abundant diatom occurring in Montreal Lake in 1987, followed by *Melosira granulata*, *Tabellaria fenestrata* and *Synedra acus*. In 1955, *Melosira* was most abundant, with *Fragilaria*, *Asterionella*, *Stephanodiscus* and *Tabellaria* common (Mendis 1956).

Quantitative analysis of net-plankton at stations A and B on Montreal Lake is given in Table 3. Plankton

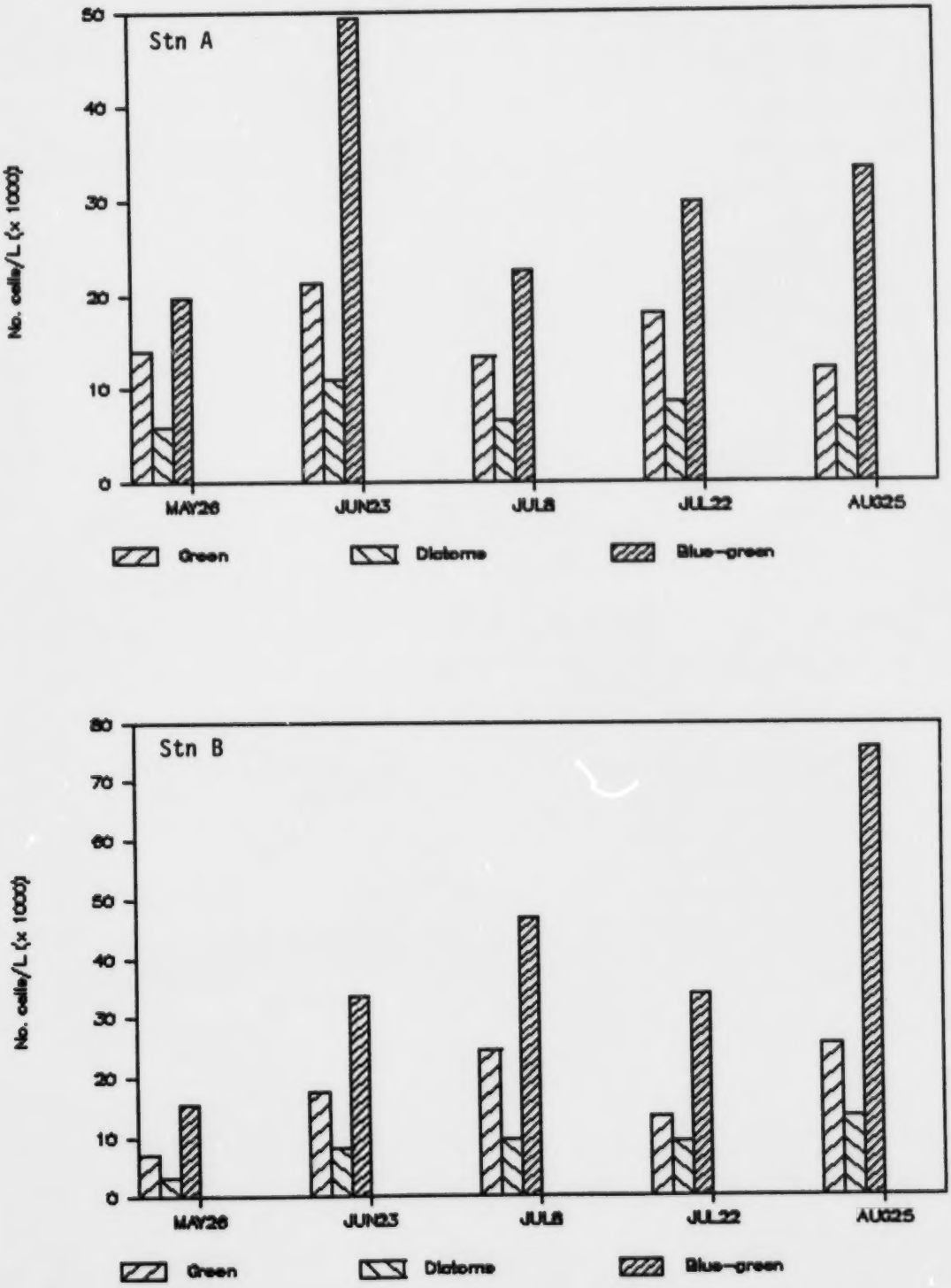

Fig. 6 Phytoplankton composition at stations A and B during the summer months, Montreal Lake, 1987.

Table 3. Quantitative analysis of net-plankton at Stations A and B, Montreal Lake, 1987 (corrected for net efficiency of 34.3%).

Date	Station	g/TVL*	% Ash	kg/ha
May 26	A	0.0384	32.5	22.8
June 9	A	0.0323	31.9	19.2
June 23	A	0.0898	30.8	53.3
July 8	A	0.0564	31.7	33.5
July 21	A	0.0374	32.6	22.2
Mean ± standard deviation		0.0509 ± 0.0236	31.9 ± 0.7	30.2 ± 14.0
June 9	B	0.1641	46.7	97.5
June 23	B	0.0874	20.1	51.9
July 8	B	0.1693	44.2	100.6
July 21	B	0.1036	42.0	61.5
Mean ± standard deviation		0.1311 ± 0.0416	38.3 ± 12.3	77.9 ± 24.8

*TVL: total vertical lift

production ranged from 19.2 kg/ha at station A on June 9 to 100.6 kg/ha at station B on July 8.. Average standing crop of plankton at station A (30.2 kg/ha) in the northern part of the lake was less than half of that at station B (77.9 kg/ha). The high plankton standing crop in the southern part of the lake suggests higher nutrient loading from watersheds to the south. Ash content varied from 20.1 - 46.7%: average ash content was 32.6% at station A and 38.3% at station B.

Mendis (1956) determined the standing crop of plankton at station B to be 53.6 kg/ha (erroneously recorded as 61.5 kg/ha), with ash content varying from 18.6 - 48.6%. These values are similar to those measured in 1987 at station B (Fig. 7). In both surveys, plankton biomass was greatest in July, the peak of the growing season.

Concentrations of chlorophyll a (an indication of the relative amount of phytoplankton standing crop) varied from 5.6 µg/L to 23.5 µg/L during the summer of 1987 (Table 4). Levels at both stations were lowest in spring and highest in late June - early July. Seasonal means at both stations were similar at 11.2 µg/L and 10.6 µg/L at stations A and B, respectively. These values are typical of lakes located in mixed wooded-cultivated watersheds (Liaw 1982).

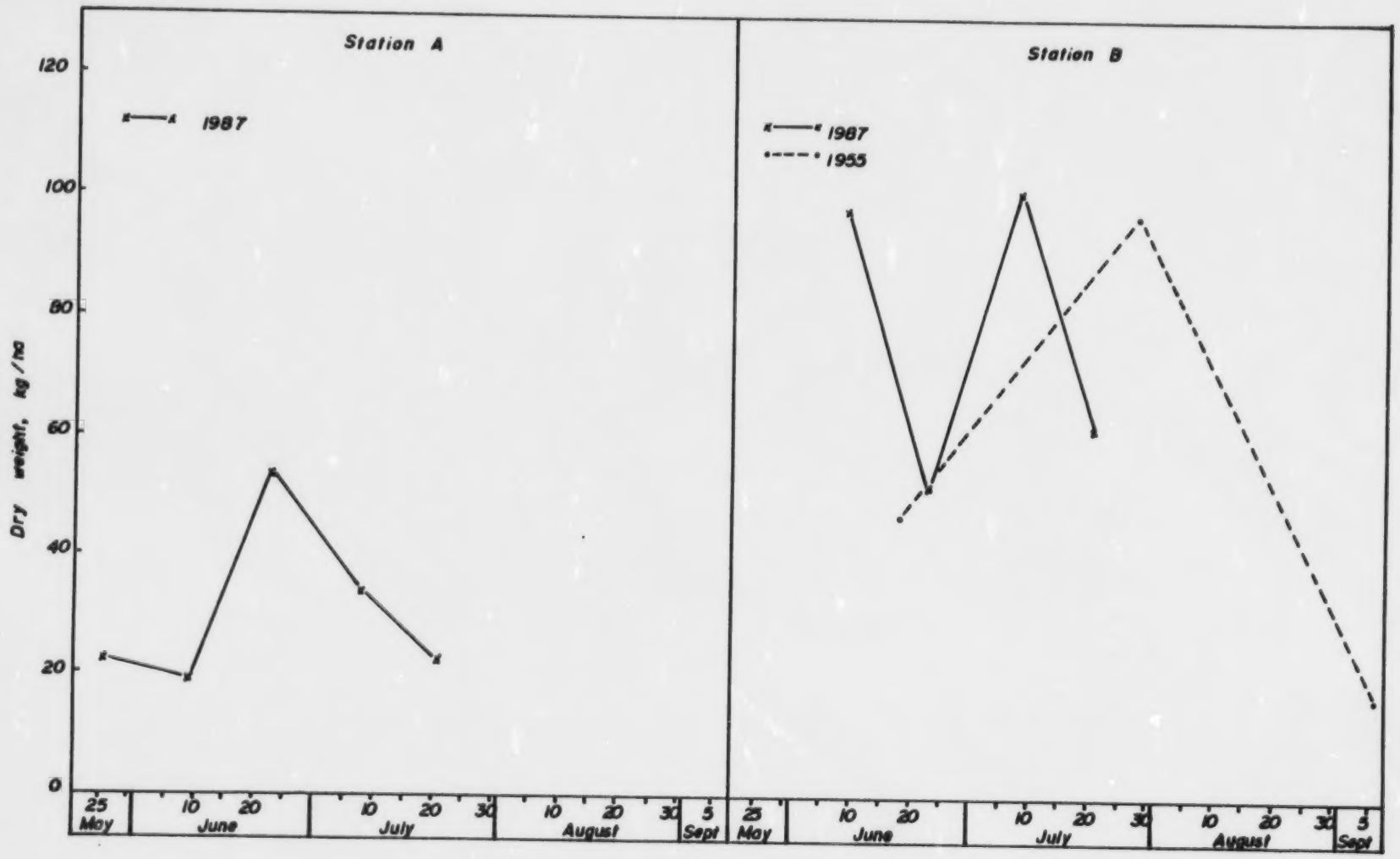

Fig. 7 Standing crop of net-plankton, Montreal Lake, 1955 and 1987.

Table 4. Levels of chlorophyll *a* (µg/L) in Montreal Lake, 1987. Values are corrected for phaeopigment:

Date	Station A	Station B
June 9	5.614	6.950
June 23	8.955	19.246
July 8	23.522	11.227
July 21	7.150	6.549
August 25	10.826	9.088
Mean	11.213	10.612

4.3 BOTTOM FAUNA

Thirty Ekman grab samples of lake sediments were taken in Montreal Lake in 1987 (Fig. 8). Numbers and weights of organisms collected are given in Appendix 4. The bottom fauna was dominated by Chironomidae (midge larvae), which comprised almost 50% of the total number of organisms sampled (Table 5). Sphaeriids (fingernail clams) were next in abundance (25.3%), followed by amphipods (freshwater shrimp) (15.0%), gastropods (snails) (5.5%) and oligochaetes (2.0%). Ephemeroptera (mayfly nymphs), Hirudinea (leeches), Plecoptera (stonefly nymphs), nematodes, turbellarians and unidentified benthos each comprised less than 2% of the total number of organisms captured. In 1955, chironomids were also the dominant organism in terms of number captured, followed by amphipods and sphaeriids (Table 6). Total number of organisms captured was 1366/m^2 in 1987, slightly more than in 1955 when 1102/m^2 were collected (Mendis 1956).

In 1987, chironomids, sphaeriids, amphipods, oligochaetes and leeches were collected from all depth zones sampled. Highest numbers of organisms/m^2 were collected in depths greater than 4 m; lowest numbers of organisms/m^2 were collected in depths less than 1 m.

In terms of dry weight of organisms, Montreal Lake has a standing crop of 17.3 kg/ha (Table 6). This value is

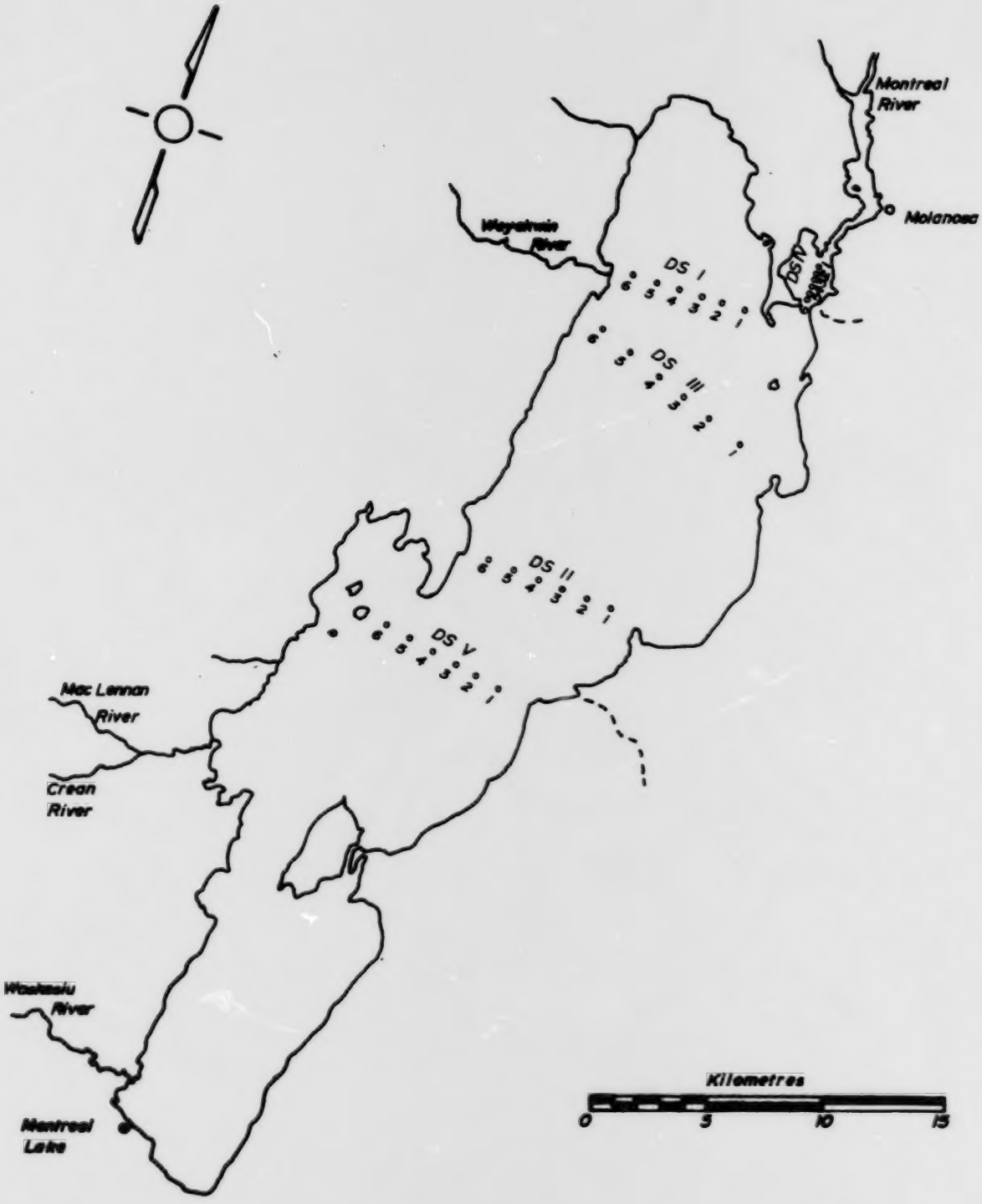

Fig. 8 Locations of dredging series taken in Montreal Lake, 1987.

Table 5. Depth distribution of benthic organisms, Montreal Lake, 1987.

Benthic organisms	No. of organisms/m^2 in the various depth zones						%
	<1	1-2	2-3	3-4	>4	All depths	
Turbellaria	-	-	4	-	-	1	<0.1
Nematoda	10	-	-	3	-	2	0.1
Oligochaeta	20	23	28	31	16	27	2.0
Hirudinea	20	10	20	14	7	15	1.1
Gammarus	-	-	4	6	-	4	0.3
Hyalella	90	407	480	-	2	201	14.7
Plecoptera	-	-	-	-	2	<1	<0.1
Ephemeroptera	50	23	60	-	2	24	1.8
Trichoptera	-	3	4	-	-	2	0.1
Chironomidae	40	223	208	1 069	1 540	669	49.0
Gastropodae	-	60	44	117	64	75	5.5
Sphaeriidae	210	140	76	600	489	346	25.3
Unidentified	-	-	-	-	2	<1	<0.1
Total no./m^2	440	889	928	1 840	2 124	1 366	
No. of dredges	2	6	5	7	9	30	
% water area	7.5	14.6	28.1	40.7	9.1	100.0	
Dry wt, g/m^2	0.70	1.43	2.68	1.35	1.84	1.73	

Table 6. Comparison of bottom fauna in Montreal Lake, 1955 and 1987. All values are weighted for percentage depth strata.

	Average no. of organisms/m^2		%	
	1955	1987	1955	1987
No. of samples	13	30		
Amphipoda	107	205	9.7	15.0
Chironomidae	864	669	78.5	49.0
Gastropoda	4	75	0.4	5.5
Sphaeriidae	92	346	8.3	25.3
Others	35	71	3.1	5.2
Total Numbers	1 102	1 366	100.0	100.0
Average dry wt, kg/ha	23.0	17.3		

similar to that determined by Mendis (1956) in 1955 (23.0 kg/ha). Benthic biomass gives an indication of the general productivity of a lake (Wetzel 1975). By comparison with other lakes in Saskatchewan, Montreal Lake is relatively unproductive. In contrast, Tobin Lake, which is one of the most productive lakes in the province, has a standing crop of nearly 100 kg/ha (Durbin 1981).

The sparse benthic community reflects the generally coarse unproductive organic debris taken in most grab samples.

4.4 FISH

4.4.1 Species Composition and Relative Abundance

Samples of the fish population in Montreal Lake were obtained by gillnetting and seining (Fig. 9 and 10). Fifteen species of fish were collected, as listed in Table 7. White sucker was the dominant species captured in the gillnets in 1987, comprising 30.5% by number and 44.7% by weight of the total catch (Appendix 5). Ciscoes ranked second in numbers, comprising 28.4% of the fish caught, but making up just 3.5% of the catch by weight. The two major gamefish species in Montreal Lake, pike and walleye, comprised 15.8% and 19.8% of the catch by number, and 21.6% and 24.8% by weight, respectively. Other species collected

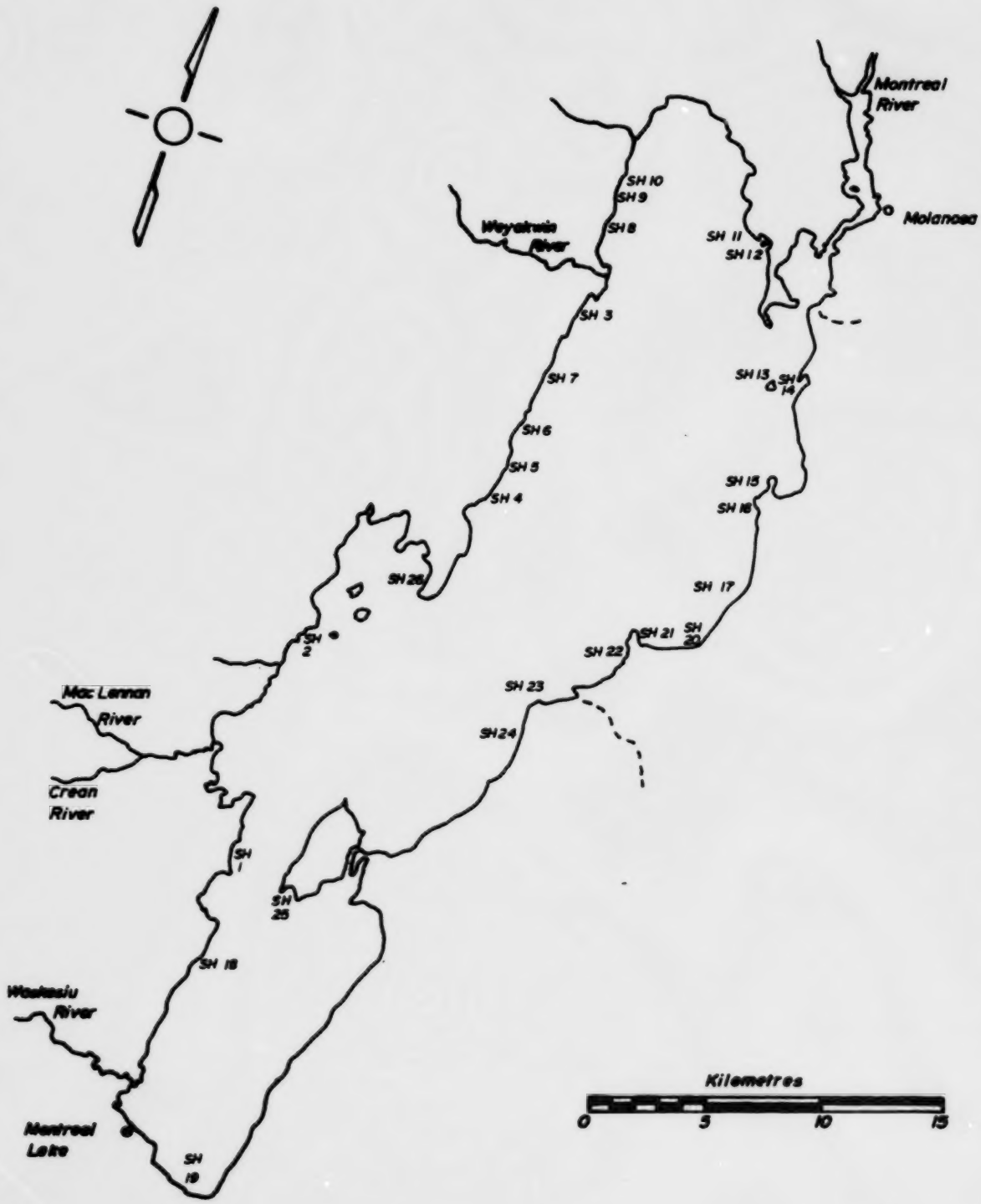

Fig. 9 Locations of seine hauls in Montreal Lake, 1987.

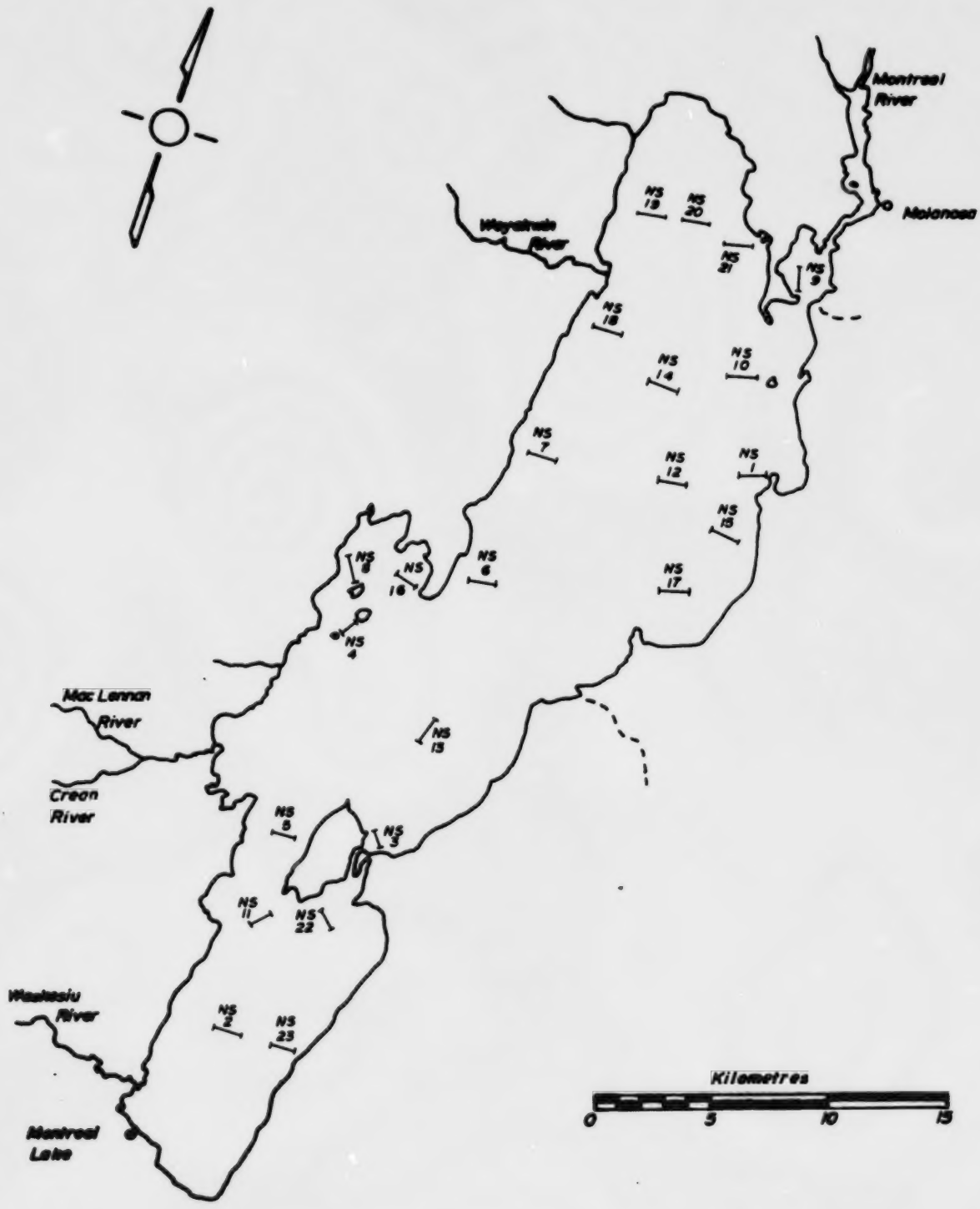

Fig. 10 Locations of gillnet sets in Montreal Lake, 1987.

Table 7. Fish species collected in Montreal Lake in 1955 and 1987.

Common Name	Scientific Name	1955	1987
Lake whitefish	*Coregonus clupeaformis*	+	+
Cisco	*Coregonus*	+	+
Northern pike	*Esox lucius*	+	+
Fathead minnow	*Pimephales promelus*		+
Blacknose shiner	*Notropis heterolepis*		+
Spottail shiner	*Notropis hudsonius*	+	+
White sucker	*Catostomus commersoni*	+	+
Trout-perch	*Percopsis omiscomaycus*		+
Burbot	*Lota lota*	+	+
Brook stickleback	*Culaea inconstans*		+
Ninespine stickleback	*Pungitius pungitius*		+
Yellow perch	*Perca flavescens*	+	+
Walleye	*Stizostedion vitreum*	+	+
Iowa darter	*Etheostoma exile*		+
Slimy sculpin	*Cottus cognatus*		+

in the gillnets consisted of lake whitefish, (3.3%) yellow perch (2.2%) and burbot (<0.1%).

Ciscoes and white suckers were also the dominant species captured in the gillnets in 1955 (Mendis 1956), but ciscoes ranked first by number (63.2%) followed by white suckers (21.8%). Walleye were third in order of relative abundance, at 8.5%.

More than 95% of the fish captured by gillnetting in 1987 were taken in the four smallest meshes ranging from 3.8 to 10.1 cm (Appendix 6). Only 1% of the fish were collected in the largest (14 cm) mesh size.

Average number of fish caught per standard gang has not changed substantially in the last three decades. In 1955, 305 fish per net set was caught (Mendis 1956). Approximately 250 fish per set were taken in 1987 (Appendix 5). The difference reflects a larger population of ciscoes present in 1955. Weights of fish caught per standard gang gillnet are not given for 1955, so changes in weight of the fish could not be determined.

Fourteen species of fish were captured by seining in Montreal Lake in 1987 (Table 8). Yellow perch were most abundant. They were collected in over 90% of the seine hauls. Spottail shiners, juvenile white suckers, fathead minnows and ninespine sticklebacks were also common in the

Table 8. Occurrence of fish species captured by seining in Montreal Lake in 1987. See Fig. 9 for location of individual seine hauls.

Species	Seine Haul Number																									%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Occurrence
Cisco																		+									3.8
Northern pike						+											+										7.7
Fathead minnow	+	+	+	+	+	+	+	+	+			+	+	+	+				+	+				+	+		65.4
Blacknose shiner														+					+	+							11.5
Spottail shiner	+		+	+	+				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	80.8
White sucker	+	+	+	+	+			+	+	+	+	+	+	+	+	+	+		+	+	+	+		+		+	80.8
Trout-perch					+								+	+	+	+	+					+	+		+		34.6
Burbot								+		+						+	+	+		+	+			+			30.8
Brook stickleback						+																					3.8
Ninespine stickleback	+	+	+	+	+	+	+	+	+	+	+		+		+	+		+	+			+			+		69.2
Yellow perch	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+		+	+	92.3
Walleye												+		+	+	+	+			+	+		+	+	+		38.5
Iowa darter	+		+	+	+	+	+	+	+	+								+	+	+					+		50.0
Slimy sculpin	+													+	+			+									15.4

seine haul samples. Several blacknose shiners were collected in the seine hauls in 1987. Although they have been collected from both Waskesiu Lake and MacLennan River (Atton and Merkowsky 1983), they have not been reported from Montreal Lake before. No juveniles of lake whitefish were collected. Up to eight species of fish were captured in each seine haul.

4.4.2 Characteristics of Major Species

4.4.2.1 Walleye

Walleye is currently the dominant gamefish species in Montreal Lake, averaging 50 fish/net set and comprising almost 20% of the total fish catch (Appendix 5). Walleye were captured in every gillnet set, and in almost 40% of the seine hauls. Relative numbers have increased since 1955 when walleye made up just 10% of the gillnet catch (Mendis 1956).

Length frequency distribution of walleye caught in the various sizes of gillnet used in Montreal Lake in 1987 is shown in Fig. 11. The 10.2 cm mesh was the most effective in sampling walleye as almost 30% of the fish were caught in this mesh. The 3.8, 5.1 and 7.6 cm meshes were equally effective in capturing walleye. Only a small number of walleye were taken in the two largest meshes.

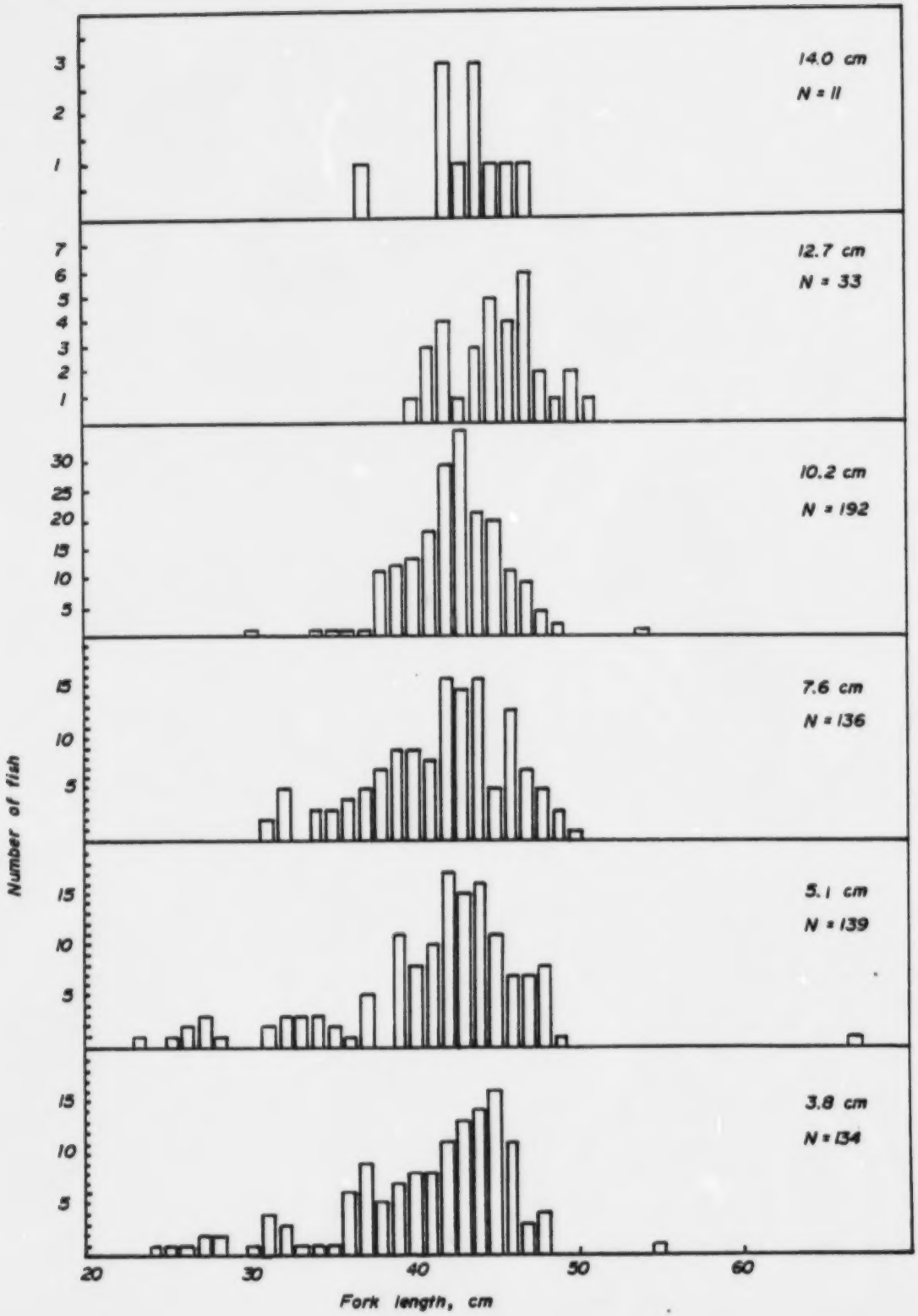

Fig. 11 Length distribution of walleye caught in the various mesh sizes of gillnet used in Montreal Lake, 1987. N = sample size.

The length-frequency distribution of the walleye sampled by gill net is shown in Fig. 12. The majority of the 645 walleye captured were between 38 and 48 cm in fork length. Average length was determined to be 42.2 cm.

The length-weight relationship is shown in Fig. 13 and is illustrated by the equation:

$$W = 0.0069\ L3.1187$$

where W is weight in grams and L is fork length in centimetres. The average weight of walleye was determined to be 851 g. The largest walleye caught in Montreal Lake was 55.0 cm long and weighed 1875 grams.

A coefficient of condition k, can be calculated by using the relationship between length and weight of a fish in the following equation, $k=WxL^{-3}$ (Carlander 1969) where W is weight in kilograms and L is fork length in centimeters. The values of k have been used by fisheries workers to express the condition, relative robustness, or "degree of well-being" of fishes. The coefficient of condition, k, varies with season, sex, sexual maturity, age and various other factors (Carlander 1969). Values tend to increase with age, as in later life fish gain proportionately more in weight per unit of length than they do in early life. Sharp changes in k occur in fish just prior to spawning and right after. K has also been used for indicating the suitability, or lack of suitability of an environment for a species by

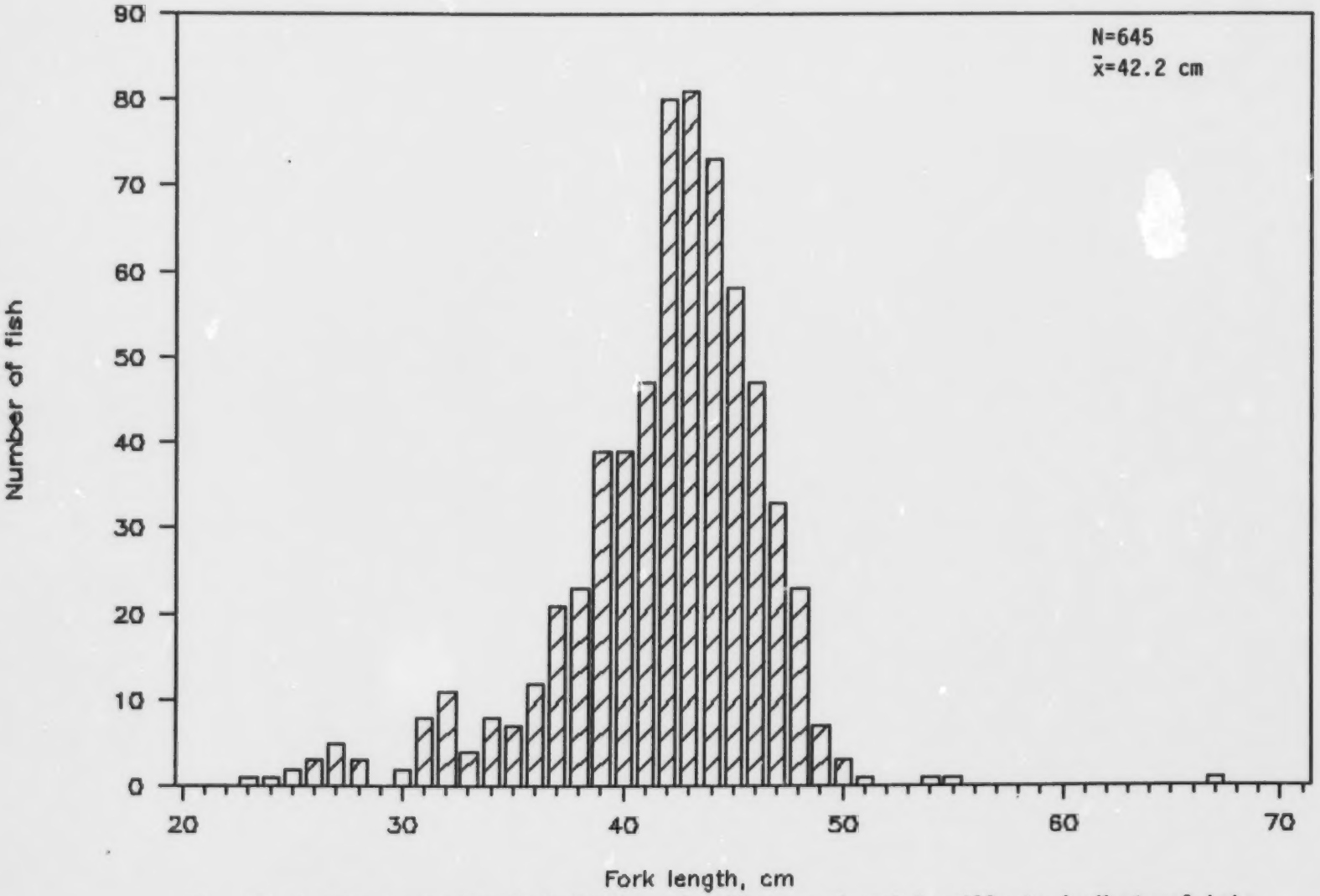

Fig. 12 Length-frequency distribution of walleye captured in gillnets in Montreal Lake, 1987. N=sample size; $\bar{x}$=mean fork length.

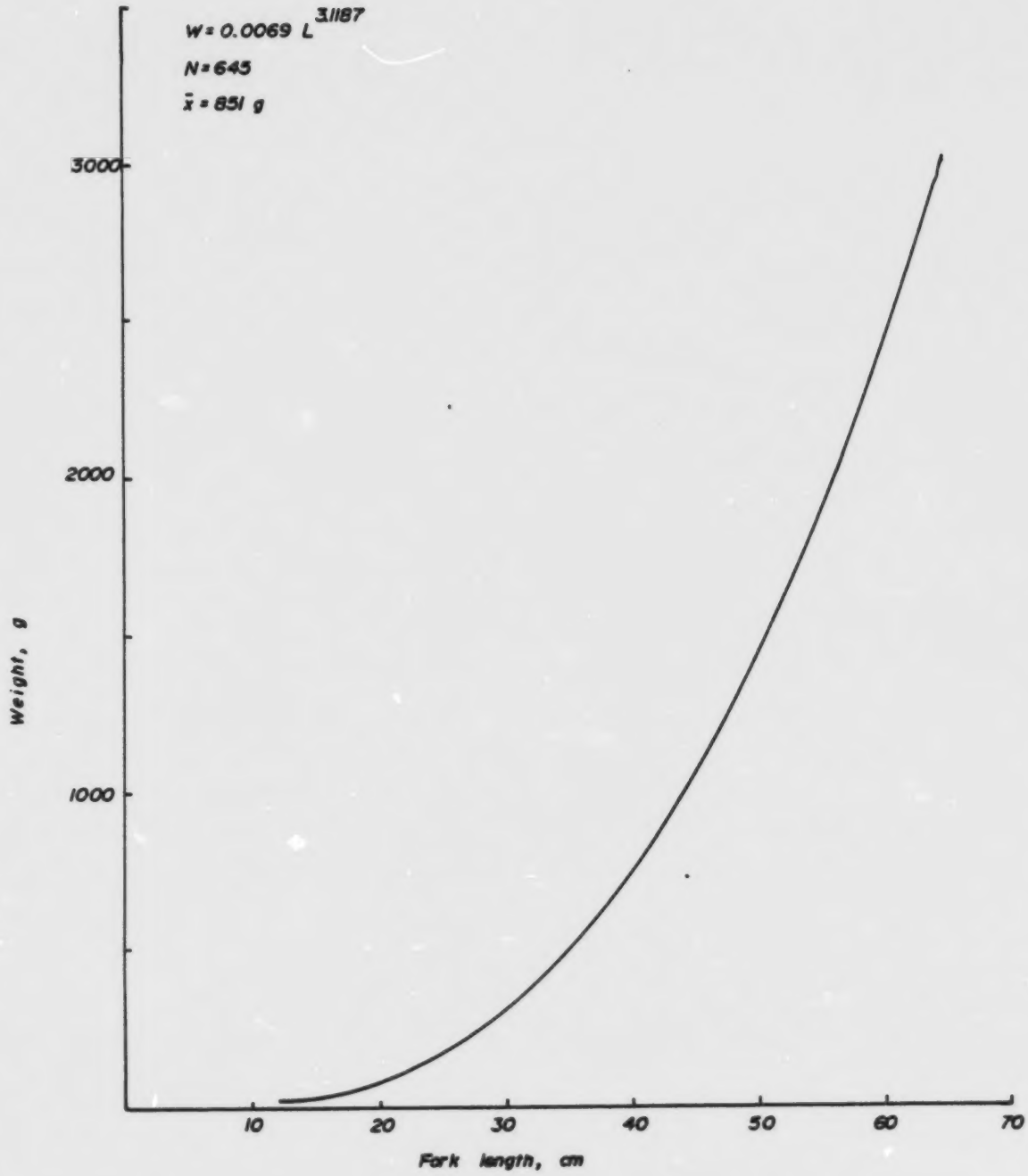

Fig. 13 Length-weight relationship of walleye captured in gillnets in Montreal Lake, 1987. N = sample size; $\bar{x}$ = mean weight.

comparison with values of fish from another region (Lagler 1956). K was calculated separately for male and female walleye from Montreal Lake captured in the gillnets during 1987:

Female K = 1.0967

Male K = 1.0681

Scales and otoliths were obtained from 104 walleye for ageing purposes based on a sample of 10 fish for each cm of length where possible. A comparison of results indicates that ages determined from the two media are similar for fish up to 7 yr old (Table 9). Since the majority of walleye were younger that 7 yr, either medium could have been used for ageing. Age composition and growth of walleye, based on scale age, are depicted in Fig. 14. Ages of walleye captured by gillnetting ranged from 2 to 10 yr. with a majority in the 5 year class. The growth rate of walleye captured in 1955 (Mendis 1956) is similar to that determined for walleye in 1987 (Fig. 14). Only 17 walleye were aged in the earlier survey however, so comparisons must be made with caution.

Size at maturity is defined as the size at which 50% of the fish have reached sexual maturity. Calculation of size at maturity for walleye is given in Appendix 7, based on the equation by Ni and Sandeman (1984). This

Table 9. Comparison of scale ages and mean otolith ages of walleye from Montreal Lake, 1987.

Scale Age, yr	Mean Otolith Age, yr	Standard Deviation	No. of Fish
2	2.0	-	1
3	3.1	0.5	17
4	4.0	0.6	17
5	5.7	0.9	25
6	6.6	0.9	22
7	7.7	0.7	15
8	13.3	1.2	3
9	13.5	-	2
10	12.5	-	2

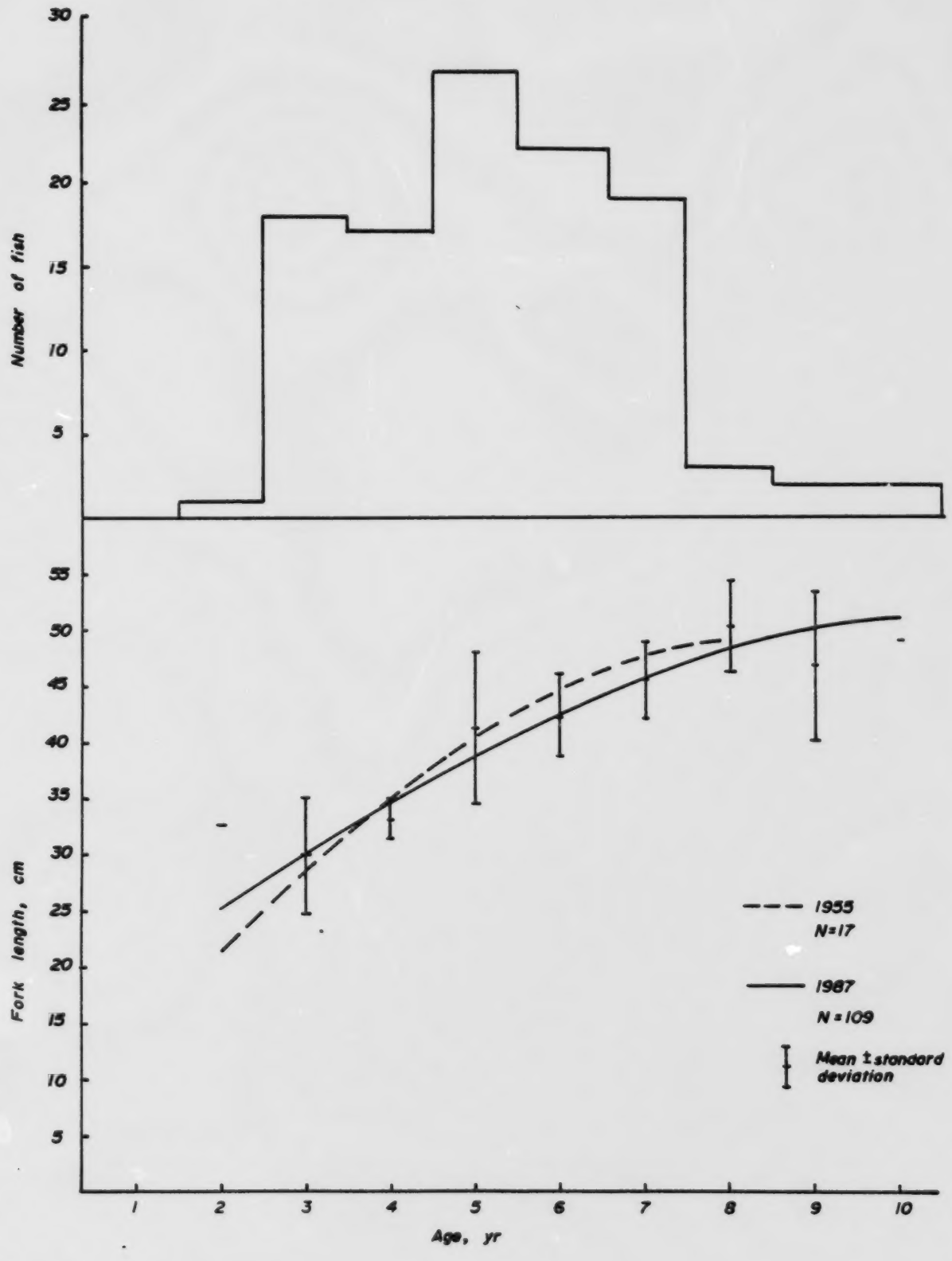

Fig. 14 Age composition and growth of walleye captured by gillnets in Montreal Lake, 1987. The growth rate of walleye captured in 1955 is also shown. Ages were determined from scales. . . sample size.

method determined that walleye in Montreal Lake mature at 39.1 cm for females and 35.9 cm for males. According to size at maturity, females would be mature at 5 yr and males at 4 yr.

Walleye spawning was not observed in Montreal Lake in 1987. However, walleye captured in the gillnets during the last week in May were spent, indicating that spawning had recently occurred. A spawning survey carried out on several tributaries to Montreal Lake in 1982 revealed that some walleye run up MacLennan River, Waskesiu River and an unnamed creek on the west shore of the lake to spawn (Chen et al. 1984). A heavy spawning run occurs in a small stream entering Montreal Lake near Molanosa. In 1987 juvenile walleye were captured in seine nets along the eastern shore of Montreal Lake (Fig. 9), confirming spawning activity in that region of the lake.

A total of 642 adult walleye stomachs were examined for food content. Results given in Appendix 8 show that fish made up almost 90% of the composition by volume of those stomachs containing food. Species identified in the stomachs included burbot, shiners, sticklebacks, perch and cisco. Other items eaten by adult walleye consisted of insects, snails, leeches, fish eggs and plant material. Only about 40% of the stomachs were empty.

In 1955, the majority of walleye had empty stomachs (Mendis 1956).

Organisms found in the stomachs of 111 small walleye captured by seining are listed in Appendix 9. Over 90% of the stomachs containing food had fish remains in them, including perch and spottail shiner. Other items eaten by juvenile walleye consisted of amphipods and insects. Fewer than 25% of the stomachs were empty.

4.4.2.2 Northern Pike

Pike made up over 15% of the gillnet catch in Montreal Lake during 1987, whereas in 1955 they comprised just over 5% of the catch by number (Mendis 1956). Pike were captured in every gillnet set in Montreal Lake in 1987 (Appendix 5), but were collected in just 7.7% of the seine hauls (Table 8).

Length distribution of pike caught in the various mesh sizes of gillnet is shown in Fig. 15. The three smallest mesh sizes (3.8, 5.0 and 7.6 cm) were most efficient, capturing almost 90% of the pike. The larger meshes were not selective for larger pike because pike tend to become entangled in the meshes rather than being gilled.

The length-frequency distribution of pike in the gillnet sample is indicated in Fig. 16. Fork lengths of

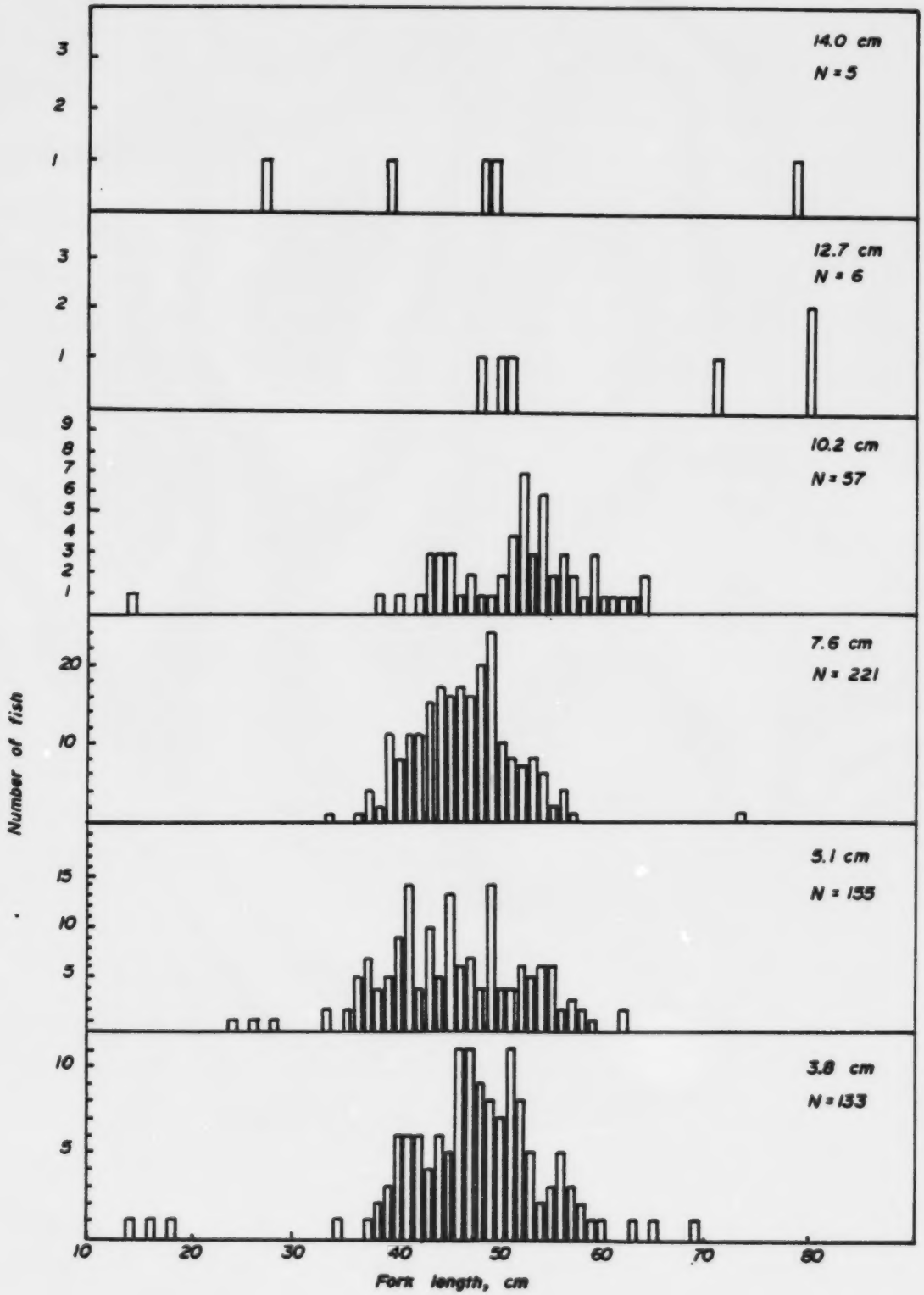

Fig. 15 Length distribution of pike caught in the various mesh sizes of gillnet used in Montreal Lake, 1987. N = sample size.

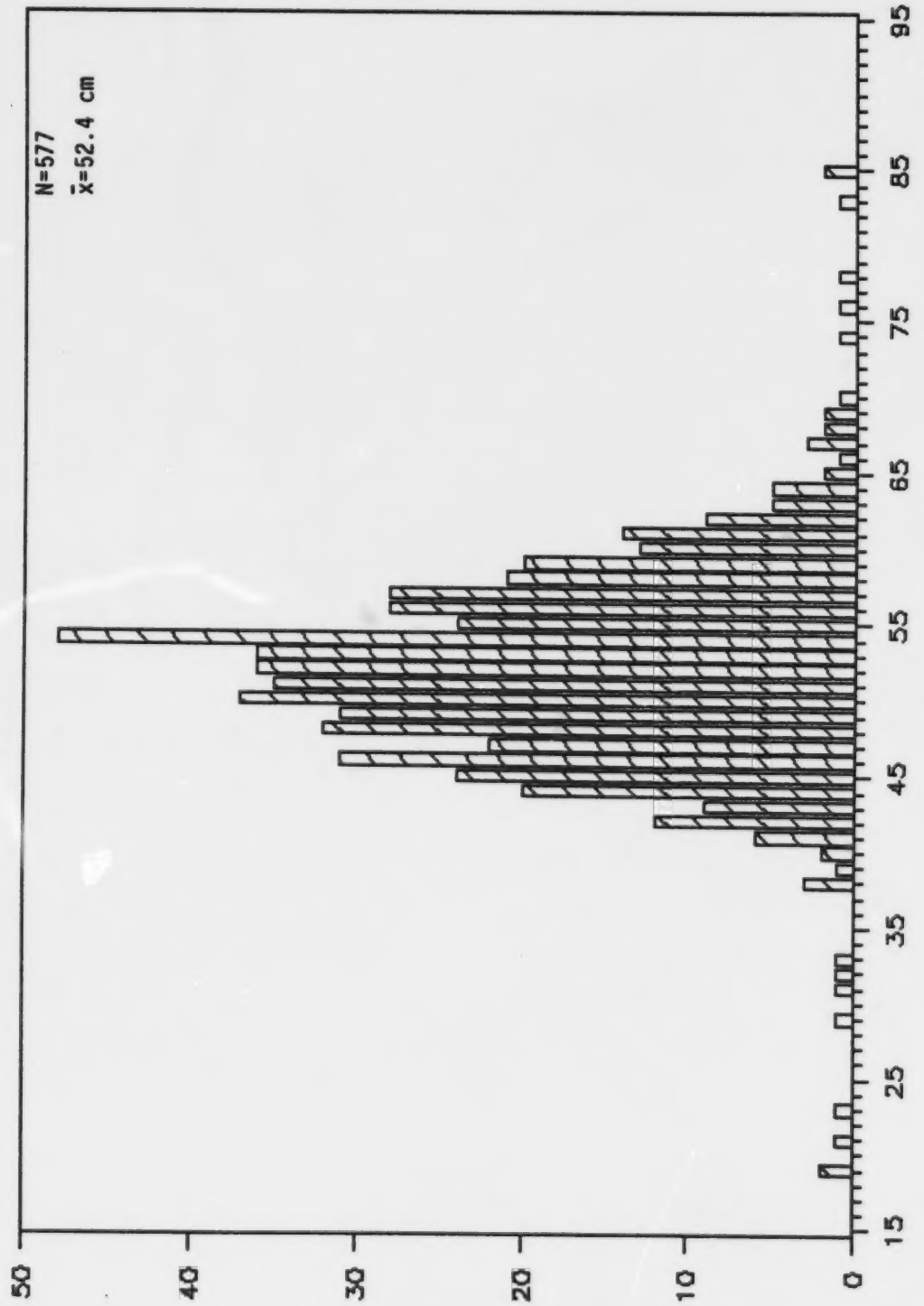

Fig. 16 Length-frequency distribution of pike captured in gillnets in Montreal Lake, 1987. N=sample size; $\bar{x}$=mean fork length.

pike captured ranged from 18 - 85 cm. The majority of the 577 pike caught were between 42 and 62 cm. Average length was 52.4 cm.

The length-weight relationship for pike is shown in Fig. 17 and is illustrated by the equation:

$$W = 0.0590\ L^{2.4292}$$

The average weight of pike was 940 g. The largest pike caught in the test netting program weighed 4800 g.

Condition factors of male and female pike from Montreal Lake was calculated:

Female K = 0.6154

Male K = 0.7198

Scales and cleithra were obtained from 261 pike in Montreal Lake for ageing purposes; where possible 10 fish were selected per cm. A comparison of results indicates that the two media give similar values (Table 10) so either scales or cleithra could have been used for ageing. Age composition and growth of pike from Montreal Lake is illustrated in Fig. 18, based on scale ages. Pike ranged in age from 1 to 8 yr, with the majority falling into the 3 - 6 yr age-classes.

Calculation of size at maturity for northern pike from Montreal Lake is given in Appendix 10. Size at

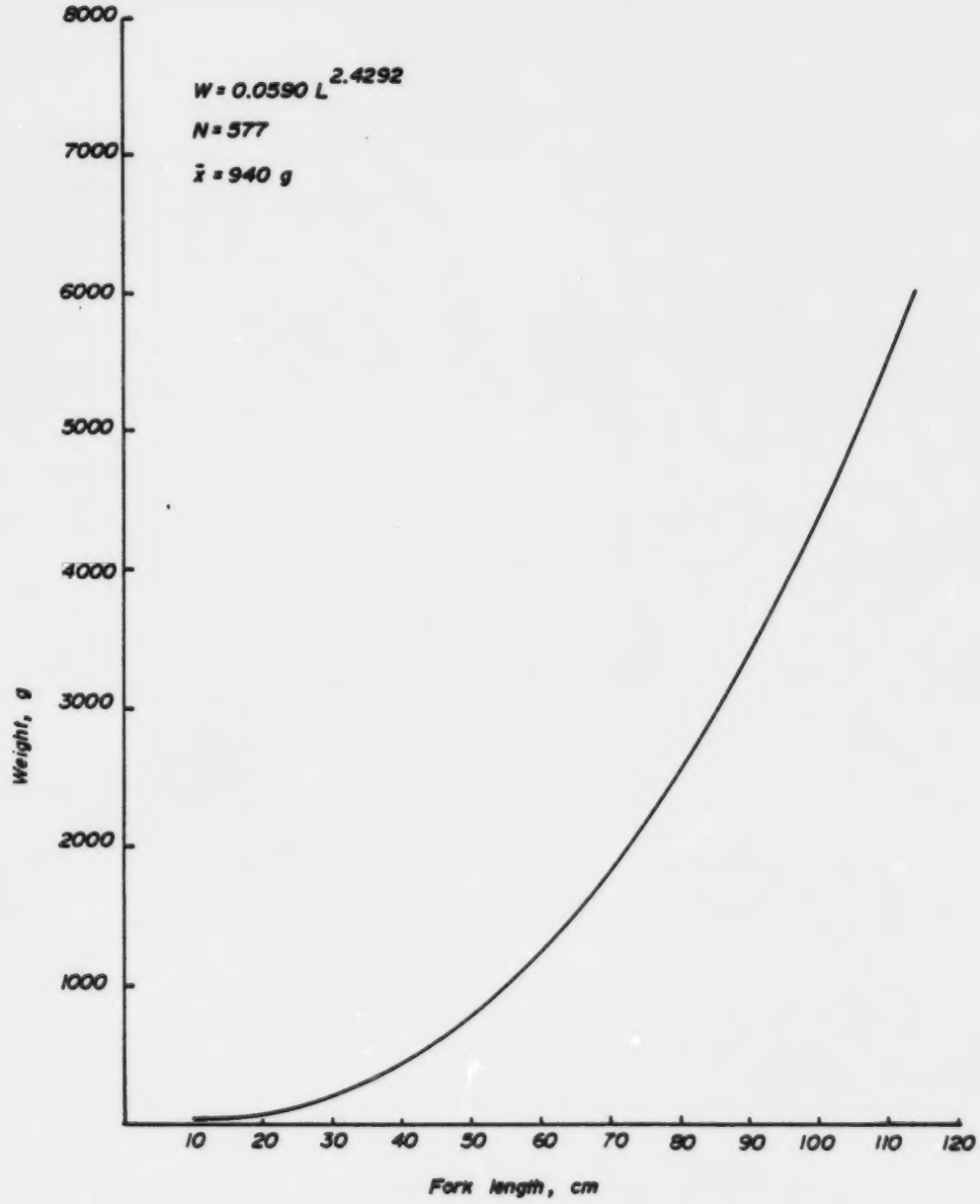

Fig. 17 Length - weight relationship of pike captured in gillnets in Montreal Lake, 1987. N = sample size ; $\bar{x}$ = mean weight.

Table 10. Comparison of scale ages and mean cleithrum ages of pike from Montreal Lake, 1987.

Scale Age, yr	Mean Cleithrum Age, yr	Standard Deviation	No. of fish
1	1.0	-	2
2	2.1	0.4	8
3	3.1	0.4	37
4	4.1	0.6	92
5	5.1	0.7	66
6	6.2	0.8	41
7	7.4	0.5	8
8	7.9	1.2	7

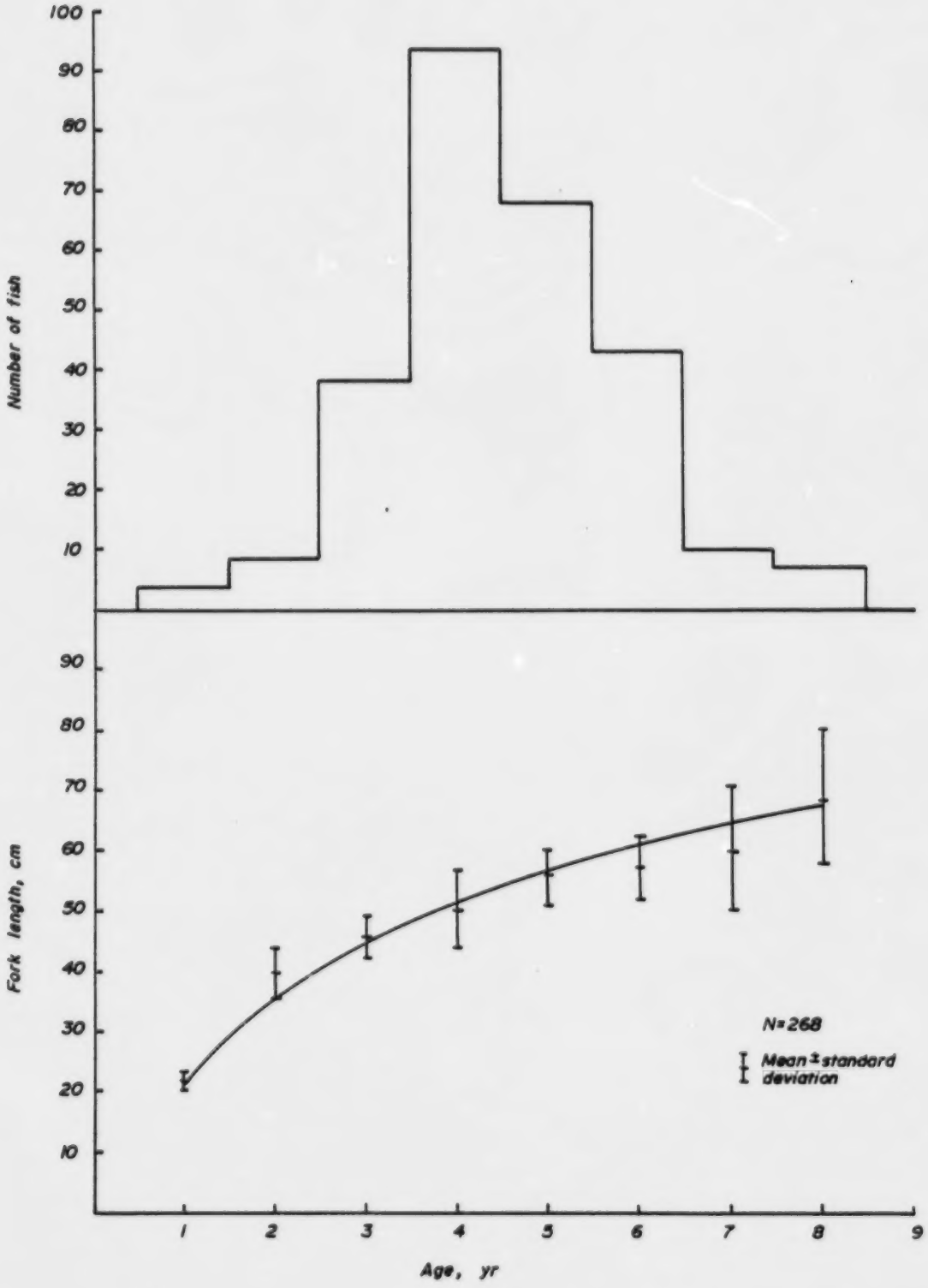

Fig. 18 Age composition and growth of pike captured by gillnets in Montreal Lake, 1987. Ages were determined from scales. N = sample size.

maturity suggests that female fish mature at 40.6 cm when they are 3 yr old. Inadequate numbers of pike in the appropriate size ranges were available to calculate size at maturity for males, but from the information available, it appears that they would mature at a smaller size.

Pike spawning normally occurs at break-up in the spring. Although spawning was not observed in Montreal Lake during 1987, pike captured in the gillnets on May 29 were spent, indicating that spawning was complete. Only a few juvenile pike were collected by seining. Areas suitable for pike reproduction (marshy, weeded areas) are not common in Montreal Lake. Some habitat occurs near Ferguson Island in the southern part of the lake. Most pike spawning probably takes place in tributaries to Montreal Lake. Pike in spawning condition were captured in gillnets set in an unnamed creek, southeast of Weyakwin in early May, 1982 (memo from R. Orr to M.E. Swanson 01/06/83) and over 1000 pike were captured in a trapnet set in MacLennan River between May 3-22, 1982 as they swam upstream to spawn (memo from F.M. Blixrud to M.E. Swanson 01/06/82).

Analysis of 550 adult pike stomachs indicated that pike in Montreal Lake rely mainly on fish as a food source. Over 85% of the stomachs with food contained fish remains (Appendix 11). Species of fish eaten by pike included stickleback (13.0%) and cisco (12.6%), with lesser amounts

of burbot, perch, sculpins, shiners, suckers, trout-perch and whitefish. Over 60% of the pike stomachs were empty.

Only 2 juvenile pike were captured by seining. One had an empty stomach, and the other contained fish fry and amphipods.

4.4.2.3 Lake Whitefish

Whitefish comprised 3.3% of the relative number of fish captured by gillnetting, and 5.2% by weight (Appendix 5) in 1987. Over 75% of the whitefish collected were taken in nets set at depths between 2 - 3 m. No juvenile whitefish were collected in the seine hauls in 1987 (Table 8). Only 3 whitefish were captured in 1955 (Mendis 1956), representing less that 0.5% of the total gillnet catch.

Length distribution of whitefish caught in the various mesh sizes of gillnet is shown in Fig. 19. The 12.7 cm mesh size was most efficient in sampling whitefish, as over 30% of the 128 whitefish were taken in it. The 3.8 and 5.0 cm meshes were effective in capturing smaller fish.

Length-frequency distribution of whitefish captured in Montreal Lake in 1987 is indicated in Fig. 20. Whitefish ranged in length from 15 - 69 cm, but the majority

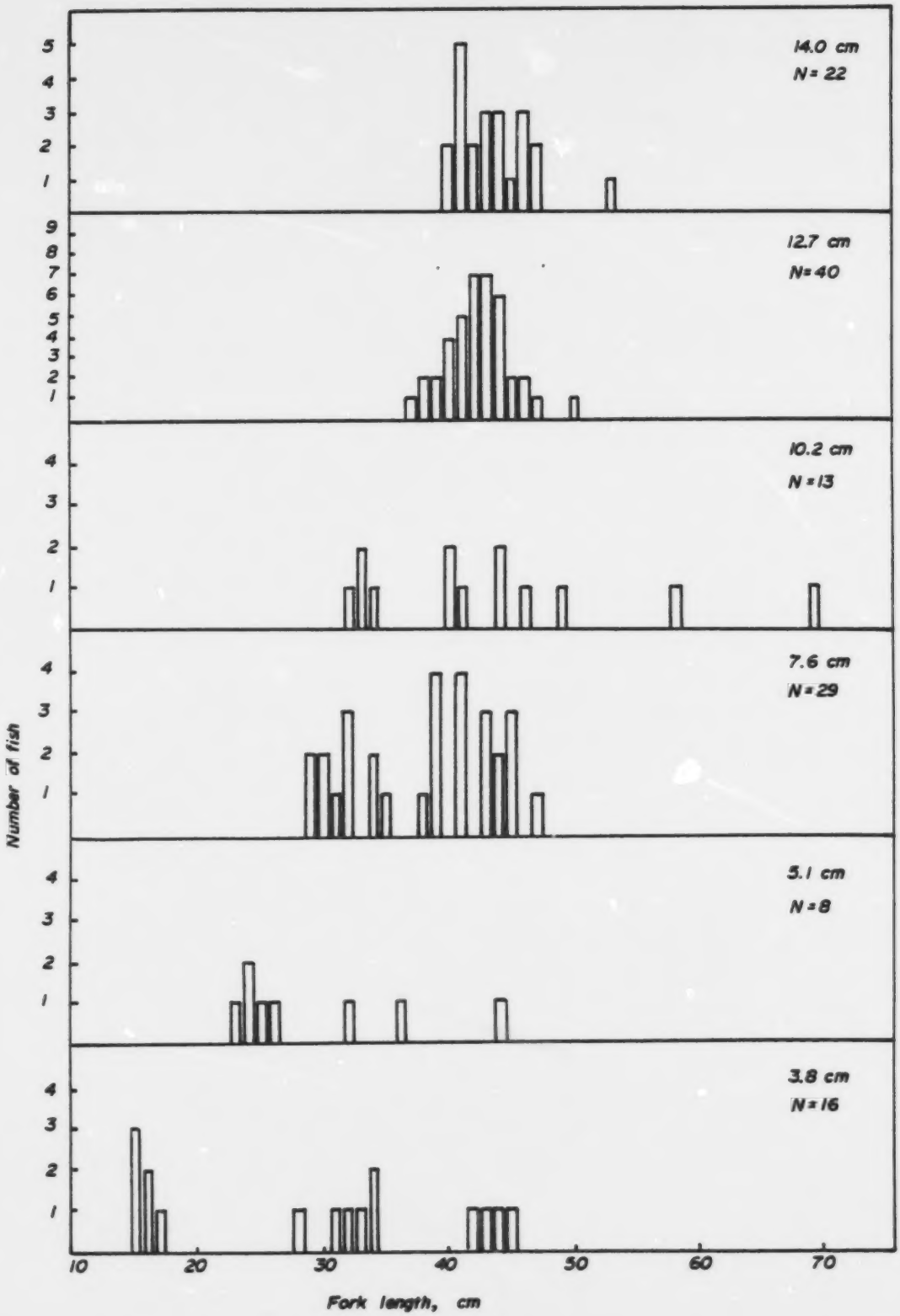

Fig. 19 Length distribution of whitefish caught in the various mesh sizes of gillnet used in Montreal Lake, 1987. N = sample size.

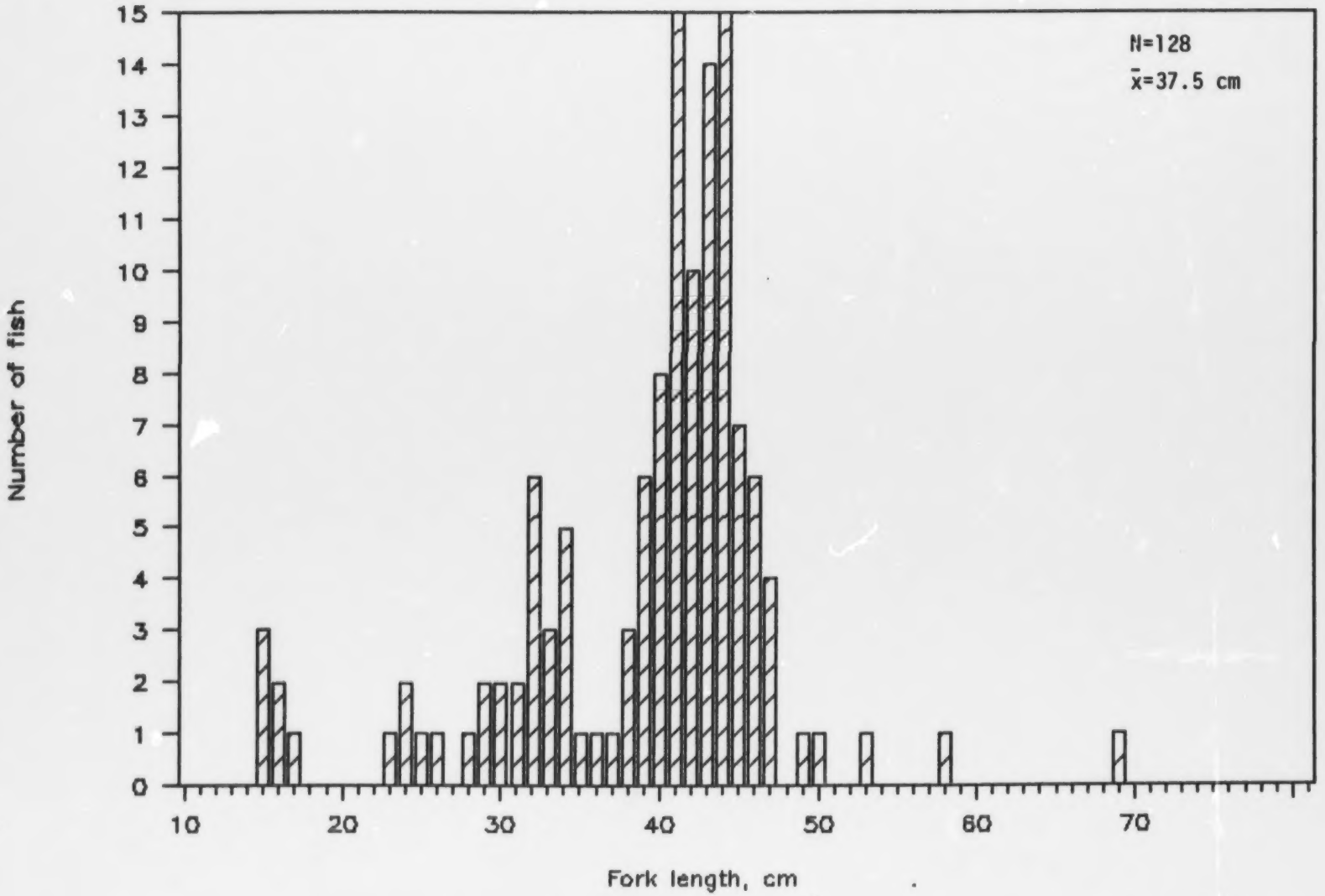

Fig. 20 Length-frequency distribution of whitefish captured in gillnets in Montreal Lake, 1987. N=sample size; $\bar{x}$=mean fork length.

fell between 38 - 47 cm. Average length was determined to be 37.5 cm. From the length-frequency distribution, several year classes of whitefish are evident.

The length-weight relationship for whitefish (Fig. 21) is illustrated by the equation:

$$W = 0.0062\ L3.2412$$

Average weight of whitefish captured in the gillnets was 1022 g. The largest whitefish taken weighed 1850 g.

Condition factors for male and female whitefish were calculated separately:

Female $K = 1.5824$

Male $K = 1.4793$

The higher value obtained for females reflects their state of maturity and gonad development.

Scales and otoliths were obtained from 90 whitefish for age determination. When results are compared (Table 11), it is apparent that the two media give similar results for whitefish up to 7 yr of age. Since the majority of whitefish in Montreal Lake were younger than 7 yr, either medium could have been used for ageing. Age composition and growth of whitefish is given in Fig. 22. Whitefish ranged in age from 0 - 9 yr, with the majority falling into the 3 - 7 yr age-classes.

Calculation of size at maturity for whitefish from Montreal Lake is given in Appendix 12. Results indicate

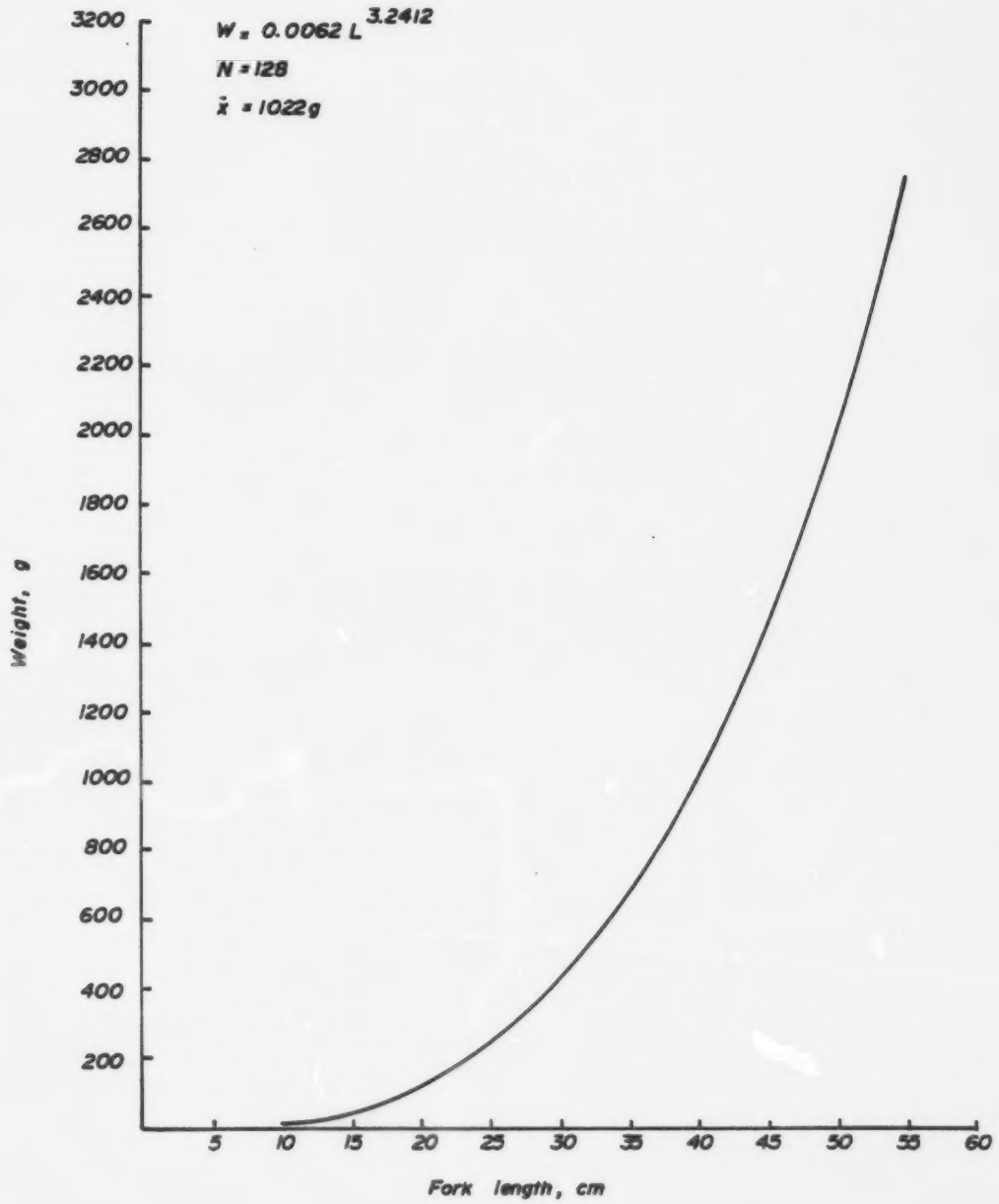

Fig. 21 Length - weight relationship of whitefish captured by gillnets in Montreal Lake, 1987. N = sample size ; $\bar{x}$ = mean weight.

Table 11. Comparison of scale ages and mean otolith ages of whitefish from Montreal Lake, 1987.

Scale Age, yr	Mean Otolith Age, yr	Standard Deviation	No. of fish
0	0.0	-	2
1	0.0	-	2
2	2.0	0.0	6
3	3.1	0.3	13
4	4.0	0.5	9
5	4.9	0.6	19
6	6.3	1.3	17
7	7.8	0.9	17
8	9.3	2.3	3
9	13.5	-	2

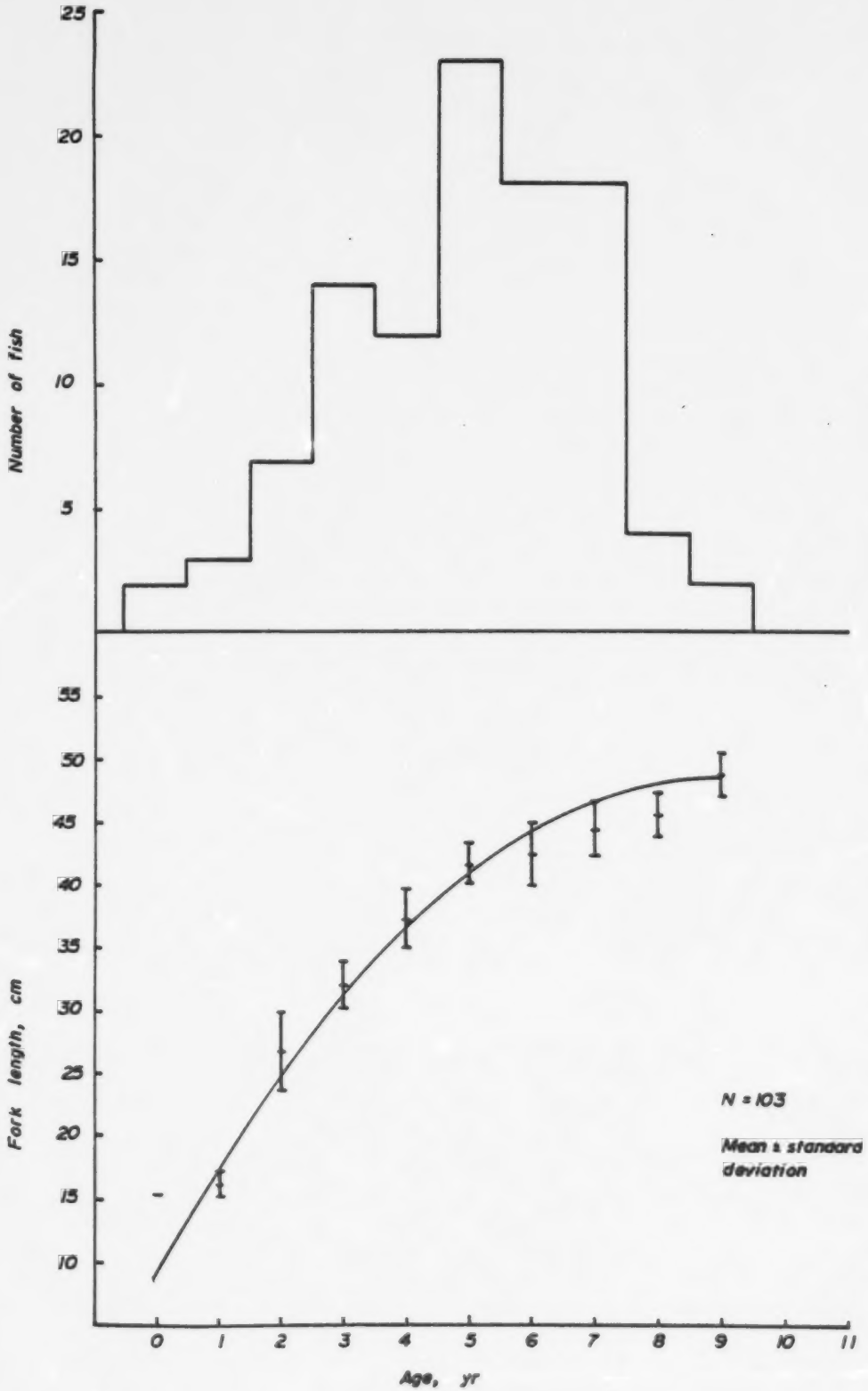

Fig. 22 *Age composition and growth of whitefish captured by gillnets in Montreal Lake, 1987. Ages were determined from scales. N = sample size.*

that female whitefish are mature at 34.0 cm, and males at 32.3 cm. According to size at maturity, both sexes would be mature by about 3-4 yr of age.

Stomach contents from 114 whitefish captured by gillnetting were examined. Of stomachs containing food, amphipods made up almost 50% by volume (Appendix 13). Insect remains made up the next largest proportion at 22.8%, and included caddisfly larvae, beetles, mayfly nymphs and water boatmen. Other organisms identified consisted of gastropods (15.8%), sphaeriids (9.6%) and fish eggs (2.2%). Less than 40% of the stomachs were empty.

4.4.2.4 Other Species

In addition to the three species discussed above, several other species of fish were captured in the gillnets in Montreal Lake.

Cisco ranked second to white sucker in abundance, comprising almost 30% of the gillnet catch in 1987 (Appendix 5). In 1955, cisco made up 63.2% of the gillnet composition (Mendis 1956). Cisco were captured in every gillnet set in Montreal Lake but in just one of the seine hauls during the present study. Almost all of the cisco were captured in the two smallest meshes. Though abundant, this species does not grow to be a large size and contributes little to the weight of fish taken in the gillnets. Average fork length of this

species was 18.7 cm and average weight was 83.8 g. Although of no economic importance, cisco are used as a food source by the major gamefish species.

White suckers were the most abundant species captured in gillnets during 1987, comprising 30.5% by number and almost 50% by weight (Appendix 5). In 1955, suckers made up 21.4% of the gillnet catch. Suckers were collected in every gillnet set, and in over 80% of the seine hauls (Table 8). All sizes of mesh captured this species (Appendix 6) but over 55% were taken in the 7.6 and 10.2 cm meshes. Average fork length of white sucker was determined to be 39.3 cm, and average weight was 992 g. Reproduction of white suckers in Montreal Lake in 1987 occurred during the latter part of May, as indicated by the capture of ripe fish in gillnets set on May 29. Spawning studies conducted in May 1983 (Chen et al. 1984) showed that suckers spawn in tributaries to Montreal Lake, such as the MacLennan and Waskesiu Rivers.

Perch were collected in 13 of the gillnets set in 1987 (Appendix 5). None were taken in gillnets in 1955 (Mendis 1956). This species comprised 2.2% by number and 0.1% by weight of the total fish catch in 1987. Perch were the most abundant fish collected by seining. They occurred in over 90% of the seine hauls (Table 8). More than 90% of the perch collected by gillnetting were caught in the

smallest mesh. Gillnets may not give an accurate assessment of the abundance of yellow perch in Montreal Lake. Average size of this fish was 14.3 cm and 42.9 g.

Two burbot were collected in the gillnets set in Montreal Lake in 1987 (Appendix 5). The occurrence of burbot in over 30% of the seine hauls (Table 8) suggests that the species may be more abundant than gillnet results indicate but find more suitable habitat in the shallow shore zones.

The abundance of forage fish present in Montreal Lake (Table 8) provides a plentiful food source for larger fish species. Although many of the species captured in the seine nets were not previously recorded from Montreal Lake, they all occur in the drainage basin and were collected from nearby waterbodies (Atton and Merkowsky 1983). The absence of many minnows and juveniles of larger species in 1955 collections is probably due to sampling effort: only one seine haul was pulled in that study (Mendis 1956).

4.4.3 The Commercial Fish Resource

Sampling of the commercial catch was undertaken on September 22 and 23, 1987 to determine the size of fish being harvested. A total of 116 whitefish were analyzed. Length distribution of the commercial whitefish samples in various years (Fig. 23) indicated that the size of fish

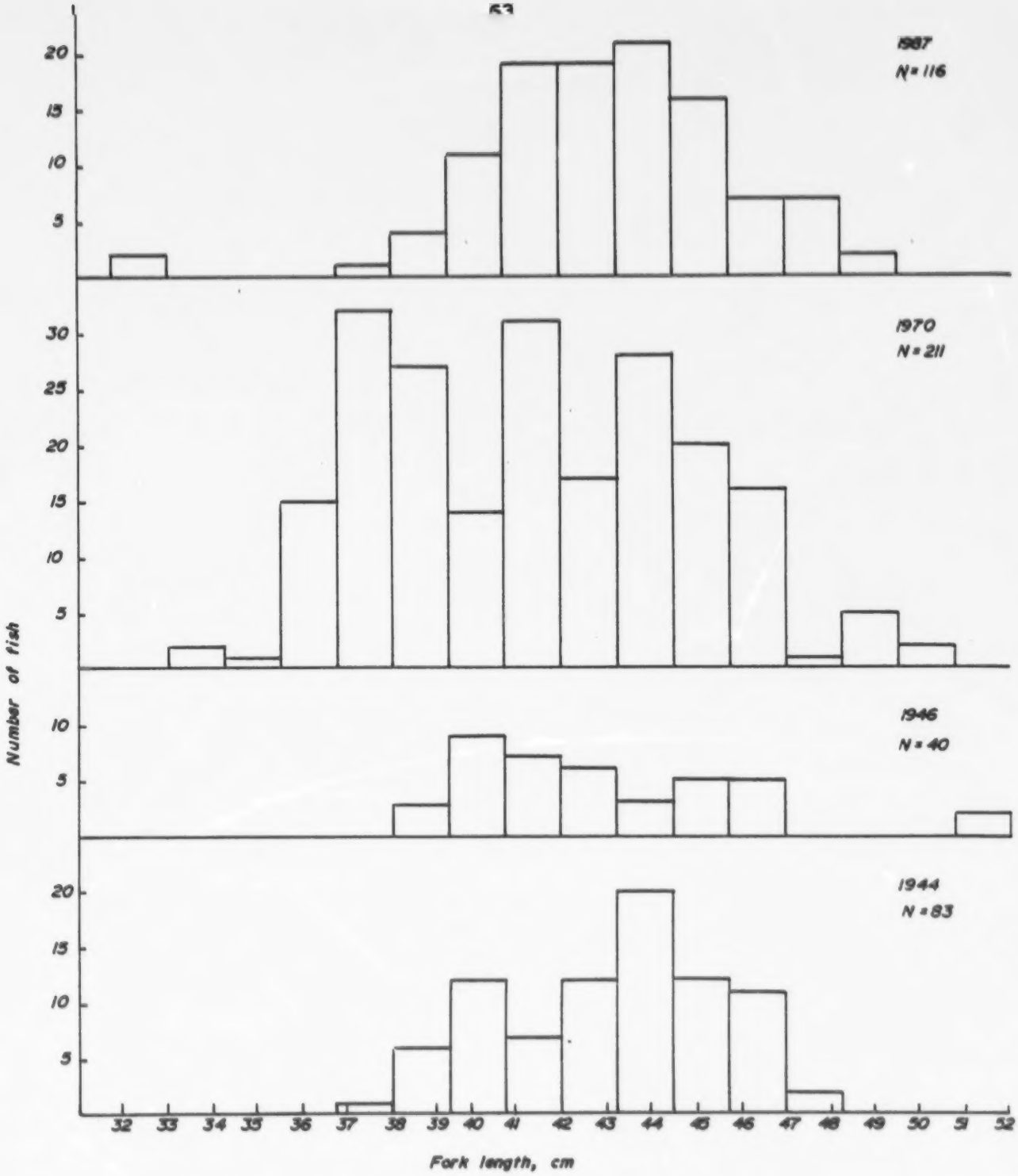

Fig. 23 Length distribution of whitefish sampled from the commercial fishery on Montreal Lake in 1944, 1946, 1970 and 1987. N = sample size.

captured in the commercial nets has not changed substantially. The majority of fish taken in 1944, 1946, 1970 and 1987 were between 37 and 47 cm in fork length. Since both sexes of whitefish attain size at maturity by 34 cm, the commercial fishery is not harvesting immature fish.

A significant factor in the suitability of lake whitefish for harvest is the extent to which they are infested by cysts of the tapeworm *Triaenophorus crassus*. Montreal Lake fish have experienced a high, and fluctuating rate of infestation. Data on infestation rates ranging back to 1975 were provided by the Department of Fisheries and Oceans (Appendix 14). Average rates on infestation have shown increases from 24.6 cysts per 100 lb of fish in 1975 to more than 250 cysts per 100 lb in 1981. In the fall of 1987 three samples produced an average rate of infestation of 112 per 100 lb. Whitefish in lakes with infestation rates of fewer than 40 cysts/100 lb are considered of export quality; those with 40-80 cysts are classified as continental and over 80 are cutters. At present summer prices of 19 cents per lb cutter whitefish are running at approximately one-half the value of similar sized fish from an export quality lake. In 1987 there was virtually no

indicates that Montreal Lake is relatively high in abundance of gamefish:

Water Body	No. of Gamefish/set	Source
Cumberland L.	182.9	Reed 1959
Montreal L.	90.0	present study
Tobin L.	70.6	Durbin 1981
Churchill R.	53.0	Liaw 1986
Jackfish L.	47.3	Durbin 1980
Delaronde L.	18.8	Liaw 1976

Gamefish included are pike, walleye, sauger and goldeye.

Walleye are the dominant gamefish in Montreal Lake. The capture of this species in every gillnet set in 1987, and in 40% of the seine hauls indicates that it is widespread throughout the lake.

Growth of walleye from Montreal Lake is intermediate when compared to the fast growing populations from Tobin Lake and the North Saskatchewan River, and the slower growing fish from Cumberland Lake and the Churchill River. (Table 12). Some of the walleye from other waterbodies were aged using otoliths whereas, those from

market for cutter whitefish. Montreal Lake is presently classified as a cutter lake.

A total of 108 walleye captured by commercial fishermen in 1987 were analyzed. The fish ranged in length from 37 to 57 cm, and weighed from 700 to 1750 g. Almost 90% of the walleye were in the 42-48 cm range and would have been 6-8 yr of age. Since both sexes of walleye in Montreal Lake reach size at maturity by 39 cm, the majority of fish taken in the commercial fishery were mature fish.

The 39 pike sampled from the commercial fishery ranged in size from 45-90 cm in fork length and weighed from 700 to 1750 g. These fish were at least 4 yr in age and sexually mature. Data presented earlier showed that all pike in Montreal Lake are mature by 40 cm.

5. DISCUSSION

5.1 FISH POPULATIONS

Fifteen species of fish were collected in Montreal Lake in 1987 compared to only 7 in 1955, presumably because of a greater effort in seine haul sampling. Numbers of fish collected per net set have not changed substantially since the earlier survey, although abundance of gamefish captured has increased. A comparison of average numbers of gamefish caught per standard gang in Saskatchewan water bodies

Table 12. Growth of walleye, pike and whitefish (fork length, mm) in Montreal Lake and other water bodies. Ages are based on scales unless indicated as otolith ages. Lakes listed in order of decreasing fork lengths at age 5+.

	Age, yr											
	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+
Walleye												
Tobin Lake[1]	148	270	377	415	469	517	553	607	646	668	679	680*
N. Sask. River[2]	214°	288°	326°	380°	425°	466°	487°	480°	541°	556°	512°	583°
Montreal Lake[3]			300	332	413	425	456	504	469*	491*		
Cumberland Lake[4]		243°	298°	372°	360°	414°	431°	414°	439°	460°	442°	447°
Churchill River[5]		203	251	253	296	320°	325°	346°	374°	409°	394°	433°
Pike												
Tobin Lake	226*	442	501	557	623	681	723	851				
N. Sask. River	288	358	404	510	574	504	617	547	621	738	830	
Hunter Bay[6+]	183	320	422	498	538	597	630	582*	627	627*		
Montreal Lake		212	314	407	511	617	738	786				
Churchill River				301	425	461	501	543	583	653	700	
Whitefish												
Montreal Lake	161	269	322	374	419	427	447	457	490*			
Jackfish Lake[7]	174	275	318	367	408	440	-	463*	488*	500*	505*	
Lac la Plonge[8]		206	244	296	341	362	375	379	394	412*		
Churchill River		197	264	294	330	373	399	415	456	477	478	489

* sample based only on 1 or 2 specimens
\+ male pike only
° otolith age
1-Durbin 1981; 2-Merkowsky 1987; 3-present study; 4-Reed 1959; 5-Liaw 1986; 6-Koshinsky 1979; 7-Liaw 1978; 8-Sawchyn 1987.

Montreal Lake were aged from scales. Since little difference occurred in ages determined from the two media for walleye less than 7 yr of age from Montreal Lake, the comparison should be valid for younger walleye.

Condition characteristics (proportions of weight to length) change with age, vary between sexes and change with the season (Lagler 1956). Female walleye from Montreal Lake had a higher condition factor than did male walleye, although according to Colby *et al.* (1979), no significant differences occurred in condition factors between the sexes for walleye in most lakes reported in the literature. Condition of walleye from Montreal Lake was less than that (1.12) reported for walleye from the North Saskatchewan River (Merkowsky 1987).

The presence of numerous year-classes, particularly older age-classes, and relatively old age at sexual maturity suggest that the walleye in Montreal Lake are not being heavily exploited at the present time.

Pike are also a dominant gamefish in Montreal Lake and, together with walleye, they are becoming increasingly important to the commercial fishery. The scarcity of pike in seine hauls is probably because seining is difficult in habitat normally occupied by young-of-the-year pike.

Growth of pike from Montreal Lake is compared to growth of populations from other water bodies in Table 12.

Pike from Montreal Lake are smaller than those from Hunter Bay, Tobin Lake and the North Saskatchewan River up to age 5 yr, but after age 6 yr their growth surpasses that of pike from all other waterbodies except Tobin Lake. This suggests that once pike in Montreal Lake reach a large size, a change in either diet or habitat provides access to more food resources.

Condition of pike from Montreal Lake (0.67) was similar to that determined for pike from Jackfish (0.73) and Murray (0.68) Lakes (Durbin 1980).

Estimation of age at maturity suggests that both sexes of pike from Montreal Lake are mature by about 3 yr of age, which is similar to age at maturity of pike from Lac la Ronge (Koshinsky 1979). In contrast, pike from the Churchill River are not mature until they are 6 yr of age (Liaw 1986).

The pike population in Montreal Lake, although abundant, is characterized by a lack of young age-classes. During test-netting in 1987 only a few pike less than 37 cm in length were captured. This suggests that pike reproduction has not been highly successful in the last few years. Many pike reproduce in tributaries to Montreal Lake. The presence of numerous beaver dams in many of these streams which causes alterations in water levels may have affected the reproductive success of pike using them as

spawning grounds. Spring run-off has been low in the last few years, and this may have prevented the development of flooded areas available for pike spawning in the past. Future pike populations may not be as strong as they are now.

Although whitefish have been the mainstay of the commercial fishery for many years, they comprised <5% of fish captured by gillnetting in 1987. Lower whitefish harvests by the commercial fishery in the last two decades may be due in part to reduced effort, because of high cyst infestation.

Montreal Lake whitefish grow faster than fish from Jackfish Lake, Lac la Plonge and Churchill River, attaining fork lengths of >40 cm by age 5 yr (Table 12).

Whitefish from Montreal Lake reach maturity by 3-4 yr, a relatively early age when compared to whitefish from the Churchill River that are not mature until they are at least 6 yr old (Liaw 1986).

The presence of numerous year classes of whitefish, a large proportion of older fish, and high mean age suggest that the whitefish stocks in Montreal Lake, although not abundant, are not being overexploited.

Fish populations appear to undergo cyclic fluctuations in many lakes. Changes in whitefish abundance have been blamed on low water levels in many Saskatchewan

lakes (Naftel 1965). However, the effects of water levels are difficult to separate from other long term processes. Events such as high winds and exposure of eggs may affect the fluctuation of whitefish populations more than changing water levels. A comparison of the commercial whitefish production from Jackfish Lake with its water level revealed only a very weak link between the two factors (Liaw 1978). The following data, collected at Montreal Lake by Hydrology Services, Environment Canada Water Survey, indicate that mean annual water levels are held relatively constant by the water control structure on the Montreal River

Year	Mean Annual Water Level, m
1977	490.306
1978	490.520
1979	490.608
1980	490.486
1981	490.504
1982	490.435
1983	490.504
1984	490.512
1985	490.686
1986	490.516
1987	490.402

Therefore, fluctuating whitefish populations in Montreal Lake are probably not related to water levels. The abundant sucker population, which comprised >30% of the gillnet catch by number and almost 50% by weight, competes for the same food resources as whitefish and may be affecting the whitefish populations. To allow the whitefish to become more abundant, some method of controlling rough fish species in Montreal Lake should be developed.

5.2 LAKE PRODUCTIVITY

Determination of fish productivity of a lake is important in establishing management plans for the utilization of the resource, and to gain information on the damaging effects of environmental changes on fish populations. In north-temperate lakes, Ryder (1965) developed a method for estimating fish production based on the morpho-edaphic index (total dissolved solids/mean depth). Other approaches have been used to estimate potential fish yield, among them bottom fauna standing crop (Matuszek 1978). Hanson and Leggett (1982) developed indices for predicting fish biomass and potential yield and determined that the best univariate predictor of fish yield was macrobenthos biomass/mean depth.

An estimate of sustained fish yield from Montreal Lake can be made using the morphoedaphic index (MEI), standing crop of bottom fauna, mean depth and lake area.

The estimates, based on various models are:

Model 1	Potential fish yield kg/ha/yr
Total, Y=0.966 MEI (Ryder 1965)	8.56
Total, log FY=0.308 log M + 0.372 log TDS - 0.348 log Z + 0.065 log A_o - 0.736 (Hanson and Leggett 1982)	6.32
Total, Ct/A = -0.5524 + 4.9307 log BFWT (Matuszek 1978)	5.55
Highly valued species, log (Cs/A)=-0.169 + 0.562 log BFWT (Matuszek 1978)	3.36

1MEI = morphoedaphic index, TDS/z; M=wet weight of bottom fauna, 130.12 kg/ha; TDS=total dissolved solids, 173 mg/L; z=mean depth, 2.2 m; A_o =water area, 444.72 km^2 ; Ct/A, y=total sustainable yield; BFWT=dry weight of bottom fauna, 17.3 kg/ha; Cs/A=sustainable yield of highly valued species (Whitefish, walleye and pike).

A comparison of the estimates for total potential yield reveals no large discrepancies among them. The estimate derived from Hanson and Leggett's (1982) model was used to determine individual species yields: this particular model incorporates both MEI and benthic standing crop, and the resulting yield was intermediate in value. Thus, the potential yield for all fish species from Montreal Lake is 6.32 kg/ha/yr.

Estimates of sustained fish yields of the three highly valued species (walleye, pike and whitefish) were determined from Y using the percent composition by weight in the standard gang catch (see Appendix 5):

Species	% catch by wt.	Estimated species yield,kg/ha/yr	Estimated species yield,kg/yr
Walleye	24.8	1.57	69 821
Pike	21.6	1.37	60 927
Whitefish	5.2	0.33	14 678
Total	51.6	3.27	145 426

The estimated species yields for walleye, pike and whitefish total 3.27 kg/ha/yr. This value is close to that determined from Matuszek's (1978) regression equation (3.36

kg/ha/yr) for the potential yield of highly valued species, suggesting that our estimates are reasonably accurate.

A comparison of actual fish harvest (Fig. 24) and the estimates of potential sustained yield indicates that Montreal Lake is very lightly fished. The estimated potential yield for individual species, and the estimated sustained yield for all important species combined (3.27 kg/ha) were much greater than mean annual commercial harvests. Although whitefish has comprised >75% of the commercial harvest up until 1980, the total harvest for this species falls far below the estimated potential yield. Only between 1958-74 did harvest levels of whitefish exceed the estimated potential species yield. Production figures however include only fish taken by the commercial fishery since there is a lack of data on the other fisheries operating on Montreal Lake.

5.3 USE OF THE FISH RESOURCE

Commercial, sport and food fishing have taken place on Montreal Lake for many years. Official harvest records are available for the commercial fishery since 1925.

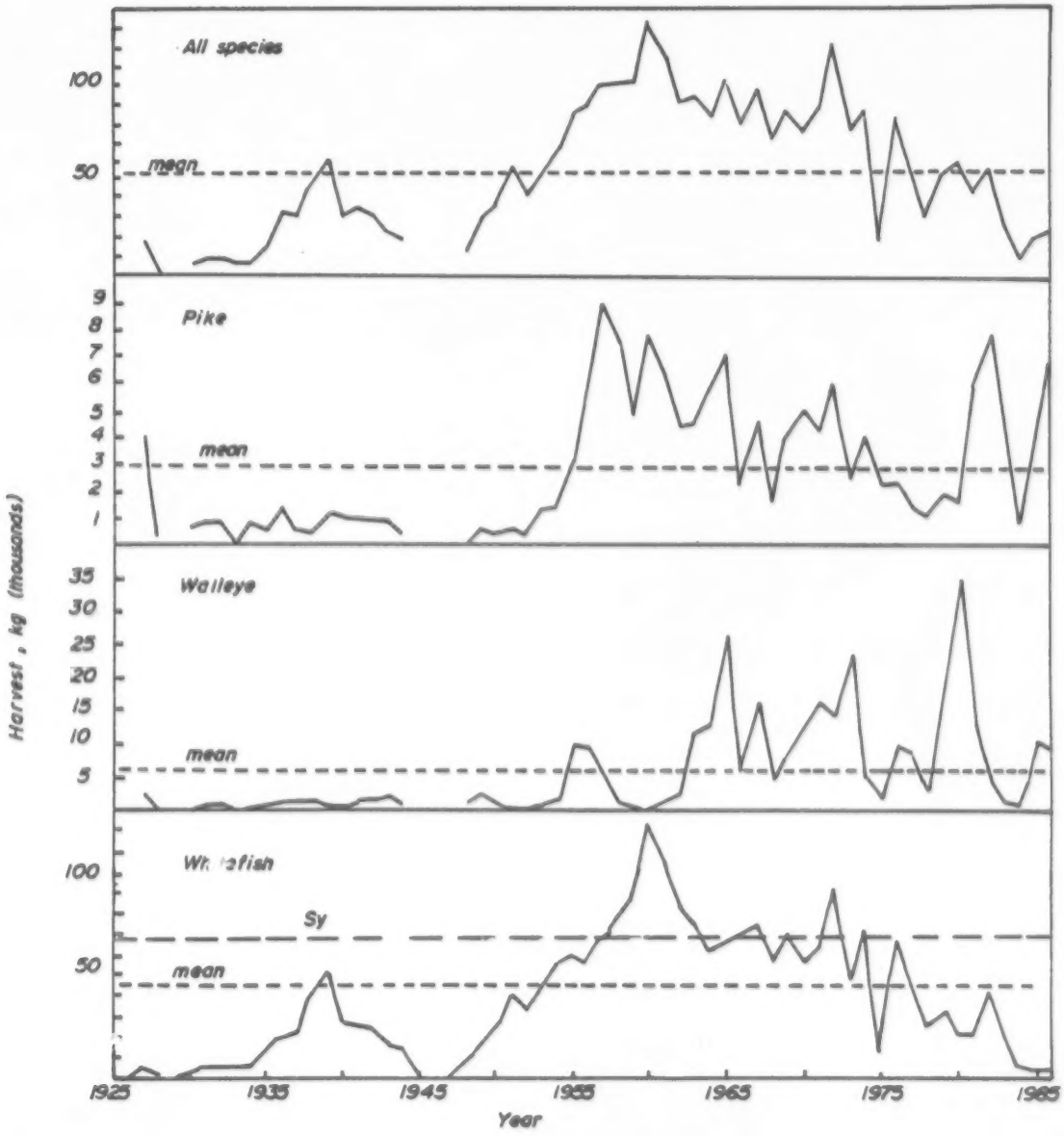

Fig. 24 Commercial production of pike, walleye and whitefish in Montreal Lake, 1925-1987. Sy = potential sustained yield.

Some estimates for food fishing harvest are available. To date, there has been no quantification of the sport fishery on Montreal Lake.

Records of domestic and Indian fish harvests are available for 12 years between 1949 and 1968 (Appendix 15). The domestic fishery harvested an estimated 11 000 kg/ha/yr during these 12 yr, and comprised whitefish (50.9%), walleye (9.0%), pike (14.0%), sucker (26.1%) and an incidental amount of burbot. Number of licenses issued annually ranged from 4 to 21.

Indian fishing permits were issued to between 21 and 105 individuals each year between 1949 and 1968. An average of 12 470 kg was harvested annually, and consisted of whitefish (47.3%), walleye (9.9%), pike (18.0%), sucker (24.8%) and a small amount of burbot.

On average, domestic and Indian fishing made up about 11% and 12% respectively, of the total net fisheries catch between 1949 and 1969, with the commercial harvest comprising the remaining 77%.

At present angling pressure on Montreal Lake during the open water season is very light. The main contributing factors are the need for large fishing boats, the lack of suitable docking and ancillary facilities and poor angling success. A strong winter ice fishery is

reported with large catches of walleye and pike being taken primarily in areas associated with winter access points.

Montreal Lake has been fished commercially at least since 1925. A quota of 27 270 kg (60 000 lb) was set on the fishery in 1941. Species included in the quota were whitefish and walleye. Originally the fishery occurred in the summer. The quota has been adjusted many times, and the season has also changed between summer and winter on several occasions. An increase in whitefish numbers was noted during the 1950s resulting in an increase in the quota to 80 000 kg in 1959. Pike was added to the species that could be fished commercially in 1970 and the quota was further raised to 90 700 kg in anticipation of the increased harvests. Currently the quota remains at 90 700 kg. Species that may be fished are whitefish, walleye and pike. Separate species quotas or gamefish tolerance limits were adopted in 1988-89. The present quota provides 56 700 kg of whitefish, 23 000 kg of walleye and 11 000 kg of pike. The legal mesh size (12.7 cm) has not changed since 1925.

Commercial fish production from Montreal Lake between 1925 and 1987 is given in Appendix 16 and Fig. 24. Commercial production has fluctuated, from a low of 1816 kg in 1928 to a maximum of 132 043 kg in 1960. The number of licenses issued annually has varied from 2 to 68. Total production is highly correlated to effort ($r=0.72$; $p<0.01$).

Average annual production is 1.18 kg/ha, comprising 75.5% whitefish, 12.0% walleye, 5.8% pike, with rough fish species (suckers and burbot) making up the remaining 6.7%.

A breakdown of average production for each decade (Table 13) indicated a steady increase in harvest up until 1970. Since 1970, production has declined, with averages during the 1980s only about half that of the 1970s. Between 1930 and 1980, average production for each decade comprised more than 75% whitefish. Since 1980 however, the harvest of whitefish has decreased and harvests of gamefish, particularly walleye, have increased. Amounts of rough fish taken, in terms of percentage of total catch, have decreased during each decade since 1925.

The quality of fish, the market demand and the prices paid are reflected in the harvesting effort and total production. In 1988-89 commercial fishermen harvested a total of 44 896 kg, of which 16 285 kg were whitefish, 23 990 kg walleye, and 4 621 kg northern pike. The species quota for walleye (23 000 kg) was reached one week after the fishery opened and resulted in closure of the commercial fishery on September 27, 1988.

Table 13. Average commercial fish production (kg) in Montreal Lake during each decade since 1925.

	Whitefish		Walleye		Pike		Other*		Total	No. licence
	kg	%	kg	%	kg	%	kg	%		
1925-1929	3 133	36.3	953	11.0	1 831	21.2	2 709	31.5	8 626	21
1930-1939	17 144	77.1	882	3.9	768	3.5	3 436	15.5	22 230	7
1940-1949	19 089	74.3	1 517	5.9	780	3.0	4 319	16.8	25 706	14
1950-1959	55 075	75.1	3 243	4.4	3 609	4.9	11 379	15.6	73 306	24
1960-1969	79 354	84.0	9 317	9.9	5 029	5.3	759	0.8	94 459	40
1970-1979	52 664	77.2	11 211	16.4	3 211	4.7	1 169	1.7	68 254	27
1980-1989	17 591	50.2	12 481	35.6	4 728	13.5	226	0.7	35 026	17

* Burbot and white sucker

5.4 MANAGEMENT IMPLICATIONS

Whitefish, walleye and pike have been commercially and domestically fished in Montreal Lake for many years. Walleye and pike are also taken by anglers, although the sport fishery harvest remains undefined. Characteristics of the stocks of walleye, pike and whitefish indicate that the fishery resource has not been intensively exploited. Rough fish (suckers, ciscoes) are the most abundant species in Montreal Lake, but they are vastly underutilized. Relative abundance of suckers has increased in the past three decades, and the large numbers of this species are providing competition for whitefish food resources.

We feel that the separate species quotas for walleye and pike could be increased to 30 000 kg and 17 000 kg, respectively, providing for a quota of 43 700 kg for whitefish based on the estimates of the potential sustained yields for the highly valued species.

Although our data suggest that the whitefish quota is well in excess of estimated sustained yield we feel that the low price and lack of demand for cutter whitefish will serve to regulate the harvest of this species. To provide a margin of safety, the total yield of all species should be a fraction of the potential yield, and the yield for an individual species a fraction of the total yield. A quota

of 90 700 kg for the commercial harvest provides an allocation of 54 726 kg for other fisheries, including domestic, sport and food fishing. If harvest data of fish taken by the sport fishery become available, the estimated sustainable yields for the separate species should be re-evaluated and the species quotas adjusted accordingly.

Whitefish has been the dominant species taken by the commercial fishery, usually comprising >75% of ir total catch. Total harvests of whitefish have generally been below the potential yield estimated for the species.

Whitefish is a coolwater species. During the hot summer months whitefish descend into the colder waters of the hypolimnion (Scott and Crossman 1973). Because Montreal Lake is relatively shallow and is exposed to prevailing winds, the waters are well-mixed and no thermal stratification develops. The temperature regime for survival of whitefish is probably borderline. It is, therefore, unlikely that whitefish stocks will ever reach the high numbers of the species present in deeper or more northern Saskatchewan lakes.

The total commercial quota should remain at 90 700 kg. To avoid overharvesting of the gamefish species, separate species quotas for the fish species remain necessary.

6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSIONS

1) A detailed fisheries survey of Montreal Lake was undertaken in the summer of 1987. This provides the first complete documentation of the biology and fish resources of one of the largest lakes in the province.

2) Montreal Lake, located about 100 km north of Prince Albert, is accessible on the west side from Highway 2 at Weyakwin, and on the east side from Highway 969.

3) Montreal Lake is situated on boreal glacial deposits. It has an area of 452 km^2 (111 724 acres), a maximum depth of 8.5 m and a mean depth of 2.2 m. It receives water from a watershed of about 700 km^2 by way of several small streams. It empties into the Churchill River drainage via the Montreal River, Bigstone Lake and Lac la Ronge.

4) The shallow depth, large area of open water and scarcity of islands provide for complete mixing during the summer months with little temperature or dissolved oxygen change between surface and bottom.

5) Water quality in Montreal Lake is typical of lakes in the forest zone (TDS 166-185 mg/L). No significant changes in major ions appear to have occurred over the

past 30 yr. Reduction in Secchi disc transparency suggests increased nutrient loading.

6) Blue-green algae are the dominant phytoplankton forms in Montreal Lake. These appear to have replaced diatoms in the last 30 yr and suggest increased nutrient loading. Total plankton biomass remained similar to that found in 1955.

7) Midge larvae (Chironomidae) were the predominant benthic organisms in Montreal Lake. Fingernail clams, amphipods, snails and sludge worms followed in decreasing order of significance. Total number of all organisms collected was 1366/m^2 in 1987, a slight increase over 1955 (1102/m^3). Montreal Lake has a standing crop of benthic fauna of 17.3 kg/ha. In 1955, 23.0 kg/ha of bottom organisms were collected.

8) Our study reported 15 species of fish in Montreal Lake in contrast to only 8 species taken in the preliminary studies of 1955. Several species of minnows were not reported in the earlier study.

9) Yellow perch were the fish most frequently caught by seining. Spottail shiners, juvenile white suckers, fathead minnows and ninespine sticklebacks were also common.

10) White suckers were the dominant species caught by gillnetting (30.5% by number). Other common species

were ciscoes (28.4%), pike (15.8%), walleye (19.8%), and whitefish (3.3%).

11) An average of 250 fish were caught per standard gang net set in 1987, 55 fish fewer than the average per net set in 1955.

12) Walleye is currently the dominant gamefish species in Montreal Lake averaging 50 fish per net set (20%). Relative numbers have increased since 1955 when walleye made up 10% of the gillnet catch.

13) The majority of walleye caught were between 38 and 48 cm in length with an average weight of 851 g.

14) Ages of walleye captured by gillnetting ranged from 2 to 10 yr with a majority in the 5 year class. Sexual maturity is reached at 4 yr in males and 5 yr in females.

15) Northern pike showed an increase in relative proportions of the total catch from 5% to 15% since 1955. The majority of the 577 caught in 23 net sets were between 42 and 62 cm in length and 3 to 6 yr old.

16) Montreal Lake supports a small population of poor quality lake whitefish. At 3.3% of the total catch, the population has not increased substantially from 0.5% of the total caught in 1955.

17) The majority of whitefish caught were large. No juveniles were caught by seining although the population

showed indications of several year classes. Most of the fish ranged from 38-47 cm and were younger than 7 yr.

18) Ciscoes ranked second to white suckers in abundance. Together they make up 60% of the fish population. Proportions of ciscoes have dropped by 100% since 1955. White sucker proportions increased by 50%.

19) The abundance of forage fish in Montreal Lake provides a plentiful food source for larger fish such as pike and walleye.

20) Montreal Lake is subjected to commercial, sport and domestic fishing. Commercial fishing records are available since 1925.

21) The number of commercial fishing licenses has ranged from 2 to 68. In the recent past 12-20 licenses have been issued. Approximately 10 domestic and 10 Indian fishing licences are issued annually.

22) On average domestic and Indian fishing accounted for 11% and 12% of the total catch with the remainder taken by commercial fishermen.

23) Currently the commercial fishing quota is set at 90 700 kg including 56 700 kg. of whitefish, 23 000 kg of walleye and 11 000 kg of pike. Average annual production has been 1.18 kg/ha, comprising 75.5% whitefish, 12.0% walleye, 5.8% pike, and 6.7% other species. Since 1980 the harvest of whitefish has

decreased and harvests of gamefish, particularly walleye have increased.

24) With the use of 12.7 cm mesh nets the commercial fishery is not harvesting immature fish.

25) Whitefish in Montreal Lake have been heavily infested with *Triaenophorus* cysts since 1979 resulting in its being classified as a cutter lake.

26) Sport fishing on Montreal Lake is light in the summer months with reportedly poor angling success. Most of the angling catch is taken by ice fishing in the winter. No data are available on the sport fish harvest.

27) The presence of numerous year-classes, particularly older age-classes and relatively old age at sexual maturity suggest that walleye in Montreal Lake are not being heavily exploited at the present time. Although pike are now established as a dominant game fish species, the lack of young age-classes suggests that future pike populations may not be as strong as they are now.

28) A large proportion of older whitefish and high mean age suggest that whitefish stocks are not being overexploited.

29) A large population of suckers is believed to be competing with the whitefish for available food resources.

30) Macrobenthos standing crop, lake depth and area were used to estimate fish yield in Montreal Lake. The values provide an estimated potential harvest of 6.32 kg/ha of fish and a sustained yield of 3.27 kg/ha of the highly valued species.

31) A comparison of actual fish harvest with potential sustained yield indicates that Montreal Lake is very lightly fished.

32) Estimated sustained yield for walleye, pike and whitefish is 69 821 kg, 60 927 kg, and 14 678 kg, respectively.

33) The present separate species quota for the commercial harvest of 56 700 kg of whitefish, 23 000 kg of walleye, and 11 000 kg of pike provide an allocation of 54 726 kg of the highly valued species for other fisheries including domestic, (Indian fishing) and angling.

34) There is a lack of recent harvest information by non-commercial fishermen although indications are that winter ice fishing for walleye is heavy. Domestic and Indian harvests have averaged 11 000 kg of whitefish, 2 200 kg of walleye, and 3 700 kg of pike prior to 1968.

6.2 RECOMMENDATIONS

1. The legal mesh size should remain at 12.7 cm. With the use of this mesh size, the commercial fishery is not harvesting immature fish.

2. The annual commercial fishery quota should remain at 90 700 kg. Separate quotas for the three economically important species remain necessary. The quotas should be adjusted to 30 000 kg (1.8 kg/ha) walleye, 17 000 kg (1.4 kg/ha) pike and 43 700 kg (0.33 kg/ha) whitefish.

3. The above allocation provides for 54 726 kg of highly valued species for the sport, domestic and Indian fisheries.

4. A sport fishery survey should be conducted to obtain information on angler harvests during both the summer and winter seasons.

5. The fish populations in Montreal Lake should be reassessed in 5 yr relative to changes in quotas and fishing pressure.

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8. APPENDICES

Appendix 1. Limnological observations at Station A, Montreal Lake, 1987. See Fig. 2 for station location.

	May	June		July		Aug.
	26	9	23	8	21	25
Station depth, m	4.0	3.5	3.8	4.5	3.8	4.1
Temperature, °C						
Air	-	20.0	20.0	20.5	21.0	17.4
Surface	14.5	14.0	19.0	16.5	18.5	14.0
1 m	11.0	14.0	18.5	16.5	17.0	13.5
2 m	10.0	13.5	18.5	16.5	15.5	13.5
3 m	10.8	13.0	18.5	16.5	15.5	13.5
Bottom	9.0	13.0	18.5	16.0	15.5	13.5
Dissolved oxygen, mg/L						
Surface	11.2	9.0	7.7	9.1	9.1	9.8
1 m	11.8	9.2	7.7	9.3	9.5	9.8
2 m	12.0	9.2	7.7	9.2	9.7	9.8
3 m	11.8	9.2	7.6	9.1	9.3	9.7
Bottom	9.2	8.6	7.5	8.4	9.0	9.8
pH						
Surface	8.3	8.2	8.0	8.2	8.2	8.3
Bottom	8.0	8.0	8.2	8.4	8.4	8.4
Secchi depth, m	1.3	0.8	1.0	0.8	0.8	0.8

Appendix 2. Limnological observations at Station B, Montreal Lake, 1987. See Fig. 2. for station location.

	May	June		July		Aug.
	28	9	23	7	21	25
Station depth, m	8.0	8.5	6.5	7.5	8.5	7.5
Temperature, °C						
Air	14.0	21.5	23.0	23.5	20.0	20.0
Surface	11.0	14.0	18.5	20.0	16.5	15.0
1 m	11.0	14.0	18.5	17.9	15.0	14.0
2 m	11.0	14.0	18.5	17.4	14.5	14.0
3 m	11.0	14.0	18.5	16.7	14.5	13.5
4 m	10.5	14.0	18.5	16.5	14.5	13.5
5 m	10.5	14.0	18.5	16.5	14.5	13.5
6 m	10.5	13.0	18.0	16.4	14.5	13.0
7 m	10.5	13.0		16.2	14.5	13.0
Bottom	8.0	12.5	18.0	16.1	14.5	13.5
Dissolved oxygen, mg/L						
Surface	10.5	10.0	8.0	8.6	8.9	9.8
1 m	10.5	10.0	8.0	9.3	8.6	10.1
2 m	10.5	10.0	8.0	9.1	8.5	9.9
3 m	10.5	10.0	8.0	8.7	8.3	9.6
4 m	10.6	9.8	8.0	8.4	8.3	9.4
5 m	10.6	9.4	8.0	8.2	8.3	8.8
6 m	10.6	8.6	8.0	6.9	8.1	7.6
7 m	10.6	8.6		6.8	7.9	7.6
Bottom	8.2	8.2	2.6	6.3	6.0	7.4
pH						
Surface	8.3	8.0	8.0	8.2	8.2	8.4
Bottom	8.0	8.1	8.2	8.4	8.0	8.3
Secchi depth, m	1.3	1.0	0.8	0.8	1.1	0.9

Appendix 3. Relative abundance (no. of cells x 1000/L) of phytoplankton in Montreal Lake, 1987.

STATION DATE	A MAY 26	A JUNE 23	A JULY 8	A JULY 22	A AUG. 25	B MAY 28	B JUNE 23	B JULY 7	B JULY 23	B AUG. 25
CHLOROPHYCEAE (GREEN ALGAE)										
Actinastrum gracilimum	0.00	0.00	0.20	0.00	0.00	0.00	0.80	0.00	0.10	1.00
Ankistrodesmus falcatus	0.40	1.20	0.80	0.50	0.40	1.00	0.00	1.20	0.00	1.00
Botryococcocus braunii	0.00	0.00	0.00	1.80	0.00	0.00	2.80	1.80	0.00	3.40
Closterium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.04
Coelastrum microporum	1.40	2.00	1.20	0.00	1.40	0.80	1.40	1.40	1.00	1.80
Cosmarium	0.00	0.00	0.00	0.00	0.08	0.00	0.08	0.08	0.00	0.08
Crucigenia quadrata	0.00	0.80	0.80	1.20	0.80	0.00	1.00	0.80	0.00	1.40
Crucigenia tetrapedia	1.00	0.00	0.50	0.00	0.00	0.00	0.00	0.08	0.80	0.00
Dictyosphaerium simplex	0.00	3.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00
Dictyosphaerium pulchellum	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.40	0.00	0.00
Elakatothrix gelatinosa	0.00	0.00	0.00	0.40	0.80	0.00	0.00	0.00	0.00	0.80
Kirchneriella obesa	0.00	1.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00
Oocystis borgei	0.40	0.50	0.80	0.80	0.80	0.00	1.00	1.60	0.80	1.00
Oocystis solitaria	0.08	0.08	0.08	0.08	0.08	0.00	0.00	0.00	0.20	0.40
Pediastrum boryanum	2.40	2.60	2.00	2.60	2.00	1.40	2.00	3.60	2.20	4.00
Pediastrum duplex	2.20	1.20	1.60	2.00	1.40	0.00	1.80	2.80	1.50	3.20
Pediastrum obtusum	1.40	2.00	1.00	1.00	1.20	1.00	0.80	1.00	1.20	1.00
Pediastrum tetras	0.00	0.80	1.00	0.00	0.00	0.00	0.80	0.40	0.80	0.00
Quadrigula chodatii	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
Scenedesmus acuminatus	1.00	1.80	0.80	1.00	0.00	1.00	0.00	1.20	0.80	0.00
Scenedesmus bijuga	0.80	1.20	0.00	1.50	0.80	1.00	1.20	1.80	0.80	1.40
Scenedesmus ecornis	0.80	1.00	1.00	2.80	1.20	0.00	1.40	1.40	1.20	2.00
Scenedesmus quadricauda	1.20	1.20	1.20	1.20	1.00	0.80	0.80	1.60	1.20	1.80
Selenastrum gracilimum	0.80	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.08
Staurastrum	0.20	0.10	0.40	0.08	0.20	0.08	0.04	0.80	0.60	0.40
TOTAL	14.08	21.28	13.38	17.96	12.16	7.16	17.52	24.44	13.20	25.60
CHRYSOPHYCEAE (GOLDEN ALGAE)										
Dinobryon sertularia	0.00	0.00	0.00	0.50	0.00	0.00	0.80	1.00	0.80	0.80
Mallomonas acaroides	0.40	0.50	0.20	0.08	0.40	0.40	0.08	0.80	0.08	0.80
TOTAL	0.40	0.50	0.20	0.58	0.40	0.40	0.88	1.80	0.88	1.60
BACILLARIOPHYCEAE (DIATOMS)										
Amphora	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Asterionella formosa	0.00	0.80	0.00	1.00	0.08	0.00	1.20	1.00	1.00	1.00

Appendix 3. (Continued)

Fragilaria crotonensis	3.00	3.80	2.80	2.00	2.40	1.00	2.80	4.20	3.80	4.20
Gomphonels herculeana	0.00	0.00	0.08	0.00	0.00	0.00	0.04	0.04	0.00	0.04
Melosira granulata	1.80	3.80	2.00	2.80	2.20	1.20	2.00	2.40	2.60	3.80
Navicula	0.10	0.10	0.08	0.08	0.08	0.08	0.04	0.08	0.08	0.10
Nitzschia acicularis	0.00	0.00	0.08	0.00	0.02	0.04	0.00	0.00	0.04	0.00
Rhopalodia gibba	0.00	0.04	0.00	0.08	0.00	0.04	0.04	0.00	0.00	0.04
Stauroneis	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stephanodiscus astrea	0.08	0.40	0.20	0.50	0.10	0.10	0.04	0.10	0.08	0.80
Surirella ovalis	0.00	0.04	0.04	0.04	0.04	0.04	0.00	0.08	0.04	0.00
Synedra acus	0.08	0.80	0.40	0.40	0.00	0.40	0.40	0.80	0.08	0.80
Synedra ulna	0.08	0.40	0.04	0.40	0.20	0.00	0.00	0.00	0.50	0.80
Tabellaria fenestrata	0.80	0.80	0.80	1.20	1.40	0.40	1.60	0.80	1.00	1.80
TOTAL	5.94	11.02	6.56	8.50	6.52	3.34	8.16	9.50	9.22	13.38
EUGLENOPHYCEAE (EUGLENOIDS)										
Euglena	0.00	0.08	0.00	0.04	0.04	0.04	0.04	0.08	0.04	0.08
Phacus	0.08	0.04	0.80	0.10	0.04	0.08	0.04	0.10	0.08	0.08
TOTAL	0.08	0.12	0.80	0.14	0.08	0.12	0.08	0.18	0.12	0.16
DINOPHYCEAE										
Ceratium hirundinella	0.00	0.10	0.10	0.04	0.01	0.04	0.04	0.10	0.20	0.20
Gymnodinium	0.10	0.00	0.08	0.04	0.04	0.40	0.08	0.08	0.10	0.10
Dinoflagellate cysts	0.00	0.00	0.00	0.08	0.04	0.00	0.08	0.20	0.00	0.08
TOTAL	0.10	0.10	0.18	0.16	0.09	0.44	0.20	0.38	0.30	0.38
MYXOPHYCEAE (BLUE-GREEN ALGAE)										
Anabaena flos-aquae	2.40	4.50	0.00	4.00	6.20	1.80	4.50	4.20	2.00	4.50
Aphanocapsa	0.00	3.50	0.00	3.50	5.20	0.00	0.00	0.00	0.00	6.00
Chroococcus limneticus	2.20	1.20	3.00	2.40	2.80	0.00	3.40	1.80	3.40	3.20
Coelosphaerium kuetzingianum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00
Coelosphaerium naegelianum	3.00	6.50	4.00	3.40	3.80	3.50	5.00	8.00	5.50	8.00
Gomphosphaeria aponina	0.00	0.00	0.80	1.40	1.20	0.00	0.00	1.00	0.50	1.80
Merismopedia glauca	0.00	0.00	0.80	3.00	0.00	0.00	1.00	1.80	0.40	2.20
Merismopedia tenuissima	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microcystis aeruginosa	12.00	32.00	14.00	12.00	14.00	10.00	18.00	26.00	22.00	50.00
Oscillatoria tenuis	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Rhabdoderma irregulare	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00
TOTAL	19.60	49.30	22.60	29.70	33.20	15.30	33.70	46.80	33.80	75.70
UNIDENTIFIED										
Flagellates	1.5	1.4	1.4	2.0	1.2	0.4	1.0	1.2	1.2	2.2
TOTAL	40.20	82.32	43.72	57.04	52.45	26.76	60.54	83.10	57.52	116.82

Appendix 4. Numbers and weights of organisms taken by dredgings (Ekman), Montreal Lake, 1987.

	May 30						June 16					
Series No.	1	1	1	1	1	1	2	2	2	2	2	2
Dredge No.	1	2	3	4	5	6	1	2	3	4	5	6
Number of:												
Oligochaeta	2	3	4	5	2					1		5
Hirudinea						2					2	3
Gammarus							1		2			
Plecoptera										1		
Ephemeroptera							15					
Trichoptera							1					
Chironomidae	2	6	51	59	69	56	1	114	83	85	120	63
Gastropodae		4		2	2	9		2	2	3	8	5
Sphaeriidae	21	7	17	39	38	68		14	16	32	27	21
Unidentified								1				
Total	25	20	72	105	111	135	18	131	103	122	157	97
Wet weight less mollusc shells, g	0.08	0.05	0.35	1.54	1.29	0.48	0.57	1.49	1.33	0.46	0.53	0.29
Depth, m	0.5	1.0	3.0	4.0	3.0	3.5	2.0	4.0	3.7	4.5	4.2	3.0

	June 16						June 18					
Series No.	3	3	3	3	3	3	4	4	4	4	4	4
Dredge No.	1	2	3	4	5	6	1	2	3	4	5	6
Number of:												
Turbellaria									1			
Oligochaeta							1		1	2	6	
Hirudinea			1				1			2	1	4
Hyalella					1	33	56	6	34	26	67	13
Ephemeroptera	1			1						1		
Trichoptera	1											
Chironomidae	2	113	69	64	57	11	21	4	2	27	33	12
Gastropodae	1	3	1	3	4		6		2	5	9	
Sphaeriidae	1	17	19	31	20	8	10	1	1	6	13	4
Total	6	133	90	99	82	52	95	11	41	69	129	33
Wet weight less mollusc shells, g	0.06	0.32	0.67	0.69	1.02	0.82	0.78	0.16	0.43	0.59	2.96	0.49
Depth, m	1.0	4.0	4.3	4.0	4.0	1.9	1.5	2.0	2.0	1.5	2.0	2.0

Appendix 4. Continued

	July 7					
Series No.	5	5	5	5	5	5
Dredge No.	1	2	3	4	5	6
Number of:						
Nematoda				1		1
Oligochaeta	1		1			
Hirudinea						2
Hyalella	7					9
Ephemeroptera	5					5
Chironomidae		12	12	30	10	2
Gastropodae	2	3	3	18	2	
Sphaeriidae	10	13	21	32	5	
Total	25	28	37	81	17	19
Wet weight less mollusc shells, g	0.67	0.16	0.13	0.29	0.28	0.52
Depth, m	1.5	3.5	4.0	3.9	3.5	0.9

Appendix 5. Gillnet summary, Montreal Lake, 1987. (Since gillnets 5-23 were half-standard gangs, numbers and weights of fish have been doubled).

Net Set	Pike		Walleye		Whitefish		White sucker		Burbot		Perch		Cisco		Total	
	No.	wt,kg	No.	wt,kg	No.	wt,kg	No.	wt,kg	No.	wt,kg	No.	wt,kg	No.	wt,kg	No.	wt,kg
1	37	31.4	20	12.4	2	2.1	185	186.3	0	0	2	0.1	8	0.7	254	233.0
2	52	59.1	1	1.3	0	0	25	19.9	0	0	0	0	72	5.9	150	86.2
3	71	60.8	66	56.3	14	12.5	120	122.1	0	0	16	0.6	70	5.5	357	257.8
4	77	84.0	51	47.8	50	54.7	139	137.5	2	2.3	13	0.4	217	17.9	549	344.6
5	22	22.3	18	17.7	2	1.5	58	57.3	0	0	0	0	182	15.4	282	114.2
6	44	35.1	56	44.9	0	0	70	75.0	0	0	0	0	122	12.5	292	167.5
7	54	43.2	32	24.1	0	0	50	50.0	0	0	8	0.4	72	6.5	216	124.2
8	28	29.2	6	3.8	14	15.5	34	36.7	0	0	22	0.9	24	2.6	128	88.7
9	20	23.8	30	26.2	4	6.0	124	138.1	0	0	12	0.5	18	1.0	208	195.6
10	36	30.8	24	21.5	2	5.1	44	43.1	0	0	0	0	28	2.9	134	103.4
11	42	51.2	14	13.3	0	0	90	87.5	0	0	4	0.2	154	13.5	304	165.7
12	36	31.9	54	46.5	0	0	110	110.4	0	0	0	0	116	9.1	316	197.9
13	32	29.2	106	94.2	0	0	56	54.3	0	0	0	0	64	5.8	258	183.5
14	48	31.0	100	76.6	0	0	54	52.3	0	0	0	0	122	10.2	324	170.1
15	46	38.3	68	52.2	10	4.0	86	76.7	0	0	0	0	42	3.8	252	175.0
16	34	30.5	48	45.0	22	19.0	74	58.2	0	0	24	1.1	20	1.8	222	155.6
17	24	23.6	26	22.4	0	0	40	40.5	0	0	2	0.1	50	5.0	142	91.6
18	28	21.4	22	18.6	22	28.9	116	106.2	0	0	12	0.8	60	5.0	260	180.9
19	50	42.9	50	43.7	20	27.5	88	87.6	0	0	0	0	64	3.8	272	205.5
20	52	43.8	144	124.4	8	10.0	26	25.4	0	0	2	0.1	32	2.4	264	206.1
21	32	30.5	130	97.4	2	0.9	36	37.6	0	0	4	0.2	8	0.7	212	167.3
22	16	14.7	18	18.6	2	2.2	80	85.9	0	0	0	0	38	2.6	154	124.0
23	36	41.1	68	67.3	16	16.8	68	70.4	0	0	6	0.2	68	4.8	262	200.6
Total	917	849.8	1 152	976.2	190	206.7	1 773	1759.0	2	2.3	127	5.6	1 651	139.4	5 812	3 939.0
Avg/set	39.9	36.9	50.1	42.4	8.3	9.0	77.1	76.5	0.1	0.1	5.5	0.3	71.8	6.1	252.8	171.3
% of Total	15.8	21.6	19.8	24.8	3.3	5.2	30.5	44.7	<0.1	0.1	2.2	0.1	28.4	3.5	100.0	100.0

Appendix 6. Fish catch distribution in various mesh sizes of gillnets used in Montreal Lake, 1987. (Equivalent of 23 standard gangs: numbers and weights of fish caught in ½ standard gangs 5-23 have been doubled.)

	Number of fish							Weight, kg						
	3.8	5.1	7.6	10.2	12.7	14.0	Total	3.8	5.1	7.6	10.2	12.7	14.0	Total
Northern pike	220	237	358	87	8	7	917	206.3	196.0	313.4	104.7	20.3	9.1	849.8
Walleye	247	249	230	346	61	19	1152	196.5	202.3	188.7	299.7	71.6	17.4	976.2
Lake whitefish	23	15	43	17	58	34	190	15.4	7.1	37.2	20.9	76.2	49.9	206.7
White sucker	57	71	425	1123	90	7	1773	44.3	38.9	381.3	1160.5	124.4	9.6	1759.0
Burbot	1	0	0	0	1	0	2	0.1	0	0	0	2.2	0	2.3
Yellow perch	121	5	0	1	0	0	127	5.0	0.5	0	0.1	0	0	5.6
Cisco	777	871	2	1	0	0	1651	50.1	89.0	0.2	0.1	0	0	139.4
TOTAL	1446	1448	1058	1575	218	67	5812	517.7	533.8	920.8	1586.0	294.7	86.0	3939.0

Appendix 7. Maturity stages of walleye from Montreal Lake, 1987.

Fork length, cm	Female				Male			
	Immature	Mature	Total	% Mature	Immature	Mature	Total	% Mature
22.1-24.0	1		1	0				
24.1-26.0	1		1	0	1		1	0
26.1-28.0	2		2	0	5		5	0
28.1-30.0	2		2	0	1		1	0
30.1-32.0	6	0	6	0	4		4	0
32.1-34.0	7	1	8	12.5	6	0	6	0
34.1-36.0	10	1	11	9.1	2	1	3	33.3
36.1-38.0	19	1	20	5.0	3	9	12	75.0
38.1-40.0	27	12	39	30.8	3	21	24	87.5
40.1-42.0	18	17	35	48.6	1	38	39	97.4
42.1-44.0	2	65	67	97.0	2	61	63	96.8
44.1-46.0	1	74	75	98.7	0	23	23	100.0
46.1-48.0	1	50	51	98.0	0	11	11	100.0
48.1-50.0	0	14	14	100.0	0	6	6	100.0
50.1-52.0	0	2	2	100.0	0	1	1	100.0
54.1-56.0	0	1	1	100.0	0	1	1	100.0
66.1-68.0					0	1	1	100.0

Calculation of size at maturity by the equation (Ni and Sandeman 1984):

$$\ln\left(\frac{P}{100-P}\right) = \alpha + \beta L$$

-where P is percent mature, L is length (using center of each length class);
-size at maturity, L(50), is defined as the size at which 50% of the fish have reached their sexual maturity; $L(50) = -\alpha/\beta$

Female: $L(50) = -\alpha/\beta = \frac{24.4383}{0.6249} = 39.1$ cm

Male: $L(50) = -\alpha/\beta = \frac{23.9281}{.66590} = 35.9$ cm

Appendix 8. Analysis of organisms found in 642 walleye captured in gillnets in Montreal Lake, 1987.

	% Composition by Volume
Insects	10.5
Fish remains:	
Shiners	0.1
Burbot	0.2
Suckers	1.0
Sticklebacks	4.8
Perch	4.4
Cisco	8.0
Unidentified	69.3
Miscellaneous*	1.7
No. of stomachs examined	642
% with food	60.3

*Includes snails, leeches, fish eggs, plant material and unidentifiable remains.

Appendix 9. Analysis of organisms found in 111 walleye captured by seining in Montreal Lake, 1987.

	% Composition by Volume				
Fork length, cm	0-4.9	5-9.9	10-14.9	>15.0	Total
Amphipods	8.3				2.4
Insects	6.3		2.6		2.4
Fish remains:					
Perch		7.9	10.5		5.8
Spottail shiner	4.2	9.2	1.3		5.6
Unidentified	81.2	82.9	80.3	100.0	82.6
Miscellaneous			5.3		1.2
No. of stomachs examined	30	47	25	9	111
% with food	80.0	80.9	76.0	44.4	76.7

Appendix 10. Maturity stages of pike from Montreal Lake, 1987.

Fork length, cm	Female				Male			
	Immature	Mature	Total	% Mature	Immature	Mature	Total	% Mature
18.1-20.0	1	0	1	0.0	0	1	1	100.0
28.1-30.0					0	1	1	100.0
30.1-32.0					1	0	1	0.0
32.1-34.0					2	0	2	0.0
38.1-40.0					0	3	3	100.0
40.1-42.0	1	3	4	75.0	0	9	9	100.0
42.1-44.0	1	6	7	85.7	0	9	9	100.0
44.1-46.0	1	22	23	95.6	0	23	23	100.0
46.1-48.0	0	20	20	100.0	0	35	35	100.0
48.1-50.0	1	24	25	96.0	0	29	29	100.0
50.1-52.0	0	36	36	100.0	0	26	26	100.0
52.1-54.0	0	31	31	100.0	0	20	20	100.0
54.1-56.0	1	47	48	97.9	0	15	15	100.0
56.1-58.0	0	37	37	100.0	0	5	5	100.0
58.1-60.0	0	34	34	100.0	0	1	1	100.0
60.1-62.0	0	17	17	100.0	0	1	1	100.0
62.1-64.0	0	10	10	100.0	0	2	2	100.0
64.1-66.0	0	4	4	100.0				
66.1-68.0	0	4	4	100.0				
68.1-70.0	0	3	3	100.0				
74.1-76.0	0	1	1	100.0				
76.1-78.0	0	1	1	100.0				
82.1-84.0	0	1	1	100.0				
84.1-86.0	0	2	2	100.0				

Female: $L(50) = -\alpha/\beta = \frac{37.9899}{0.9354} = 40.6$ cm

Male: Inadequate data to calculate size at maturity using the equation

$$\ln\left(\frac{p}{100-p}\right) = \alpha + \beta L$$

Appendix 11. Analysis of organisms found in 550 pike captured in gillnets in Montreal Lake, 1987.

	% Composition by Volume
Insects	8.9
Leeches	1.8
Gastropods	0.3
Fish remains:	
Burbot	1.0
Cisco	12.6
Perch	3.8
Sculpin	1.5
Shiners	0.5
Stickleback	13.0
Suckers	2.0
Trout-perch	1.2
Whitefish	0.5
Unidentified	50.9
Miscellaneous*	2.0
No. of stomachs examined	550
% with food	36.9

*Includes fish eggs and detritus.

Appendix 12. Maturity stages of whitefish from Montreal Lake, 1987.

Fork Length, cm	Female				Male			
	Immature	Mature	Total	% Mature	Immature	Mature	Total	% Immature
22.1-24.0	1	0	1	0.0				
24.1-26.0	2	0	2	0.0				
28.1-30.0	3	0	3	0.0				
30.1-32.0	0	2	2	100.0	2	2	4	50.0
32.1-34.0	3	1	4	25.0	1	2	3	66.7
34.1-36.0	1	1	2	50.0	2	1	3	33.2
36.1-38.0	0	2	2	100.0	0	1	1	100.0
38.1-40.0	0	7	7	100.0	0	6	6	100.0
40.1-42.0	0	15	15	100.0	0	8	8	100.0
42.1-44.0	0	11	11	100.0	0	9	9	100.0
44.1-46.0	0	12	12	100.0	0	8	8	100.0
46.1-48.0	0	7	7	100.0	0	1	1	100.0
48.1-50.0					0	1	1	100.0
50.1-52.0					0	1	1	100.0
56.1-58.0	0	1	1	100.0				
68.1-70.0	0	1	1	100.0				

Female: $L(50) = -\alpha/\beta = \frac{52.6158}{1.5476} = 34.0$ cm

Male: $L(50) = -\alpha/\beta = \frac{32.3346}{1.0013} = 32.3$ cm

Appendix 13. Analysis of organisms found in 114 whitefish captured by gillnetting in Montreal Lake, 1987.

	% Composition by Volume
Insects:	
Caddisfly larvae	1.4
Chironomid larvae	0.3
Predaceous diving beetles	1.4
Whirlygig beetles	1.4
Mayfly nymphs	3.6
Water boatmen	3.3
Unidentified	11.4
Amphipods	49.6
Gastropods	15.8
Sphaeriidae	9.6
Fish Eggs	2.2
No. of stomachs examined	114
% with food	60.5

Appendix 14. Levels of infestation of lake whitefish by cysts of *Triaenophorus crassus*.

Date Sampled	Pounds Cut	Rate of Infestation (No./100 lb)	Yearly Average
12/12/75	88	24	24
25/09/76	20	10	
27/09/76	20	20	
30/09/76	24	25	
01/10/76	30	30	
04/10/76	32	28	
07/10/76	32	28	
08/10/76	32	28	
09/10/76	40	30	
11/10/76	40	30	
13/10/76	70	30	27.3
30/09/77	20	30	
03/10/77	20	30	
10/10/77	30	30	30.0
11/04/78	8	0	
13/10/78	28	179	
16/10/78	11	236	
16/10/78	10	180	
16/10/78	12	283	
16/10/78	11	309	202.5
08/06/79	52	133	
10/09/79	64	238	
10/09/79	67	231	
21/09/79	29	155	
07/10/79	15	205	
14/10/79	26	196	
17/10/79	21	300	
17/10/79	21	338	
17/10/79	21	376	
17/10/79	23	321	238.3
10/09/80	32	97	
10/09/80	56	173	
10/09/80	30	120	130.0
03/11/81	15	293	
03/11/81	17	282	
03/11/81	17	200	258.3
24/09/82	44	70	
24/09/82	26	158	
24/09/82	26	196	141.3
13/10/83	25	52	
14/10/83	25	108	
19/10/83	18	122	
19/10/83	12	275	
19/10/83	19	132	137.8
29/09/85	22	172	172.0
06/10/86	24	111	111.3
28/09/87	10	73	
08/10/87	12	136	
15/10/87	12	128	112.3

Appendix 15. Total weights of fish (kg) taken by the various fisheries on Montreal Lake between 1949 and 1968. Domestic and Indian permit takes are estimates.

	Whitefish	Walleye	Pike	Sucker	Burbot	Total	No. Licenses
1. Domestic Harvests							
1948-49	1 360	360	180	320	0	2 220	4
1949-50	680	270	230	540	0	1 720	4
1953-54	1 360	90	270	900	0	2 620	12
1954-55	1 590	180	300	1 140	0	3 210	14
1955-56	1 800	180	360	900	0	3 240	12
1956-57	1 800	180	360	900	0	3 240	15
1957-58	2 270	180	450	900	0	3 800	20
1958-59	3 630	900	900	1 360	0	6 790	
1962-63	3 630	900	1 360	220	90	6 200	21
1963-64	15 900	3 200	6 350	6 800	0	32 250	21
1966-67	17 250	3 200	3 630	11 350	0	35 430	19
1967-68	15 900	2 270	4 080	9 080	0	31 330	11
Total	67 170	11 910	18 470	34 410	90	132 050	
Average	5 600	990	1 540	2 870	10	11 000	
2. Indian Permit Harvests							
1948-49	1 810	400	270	3 630	0	6 110	59
1949-50	2 270	400	360	1 590	0	4 620	59
1953-54	1 810	450	180	1 360	0	3 800	85
1954-55	2 270	450	230	1 360	0	4 310	85
1955-56	2 270	450	360	900	0	3 980	75
1956-57	450	450	2 720	900	0	4 520	105
1957-58	450	450	1 820	900	0	3 620	60
1958-59	1 360	900	1 820	1 360	0	5 440	
1962-63	1 360	450	900	140	50	2 900	40
1963-64	22 700	4 080	8 170	11 350	0	46 300	43
1966-67	18 160	3 630	4 540	6 800	0	33 130	41
1967-68	15 890	2 720	5 450	6 800	0	30 860	21
Total	70 800	14 830	26 820	37 090	50	149 590	
Average	5 900	1 240	2 240	3 090	5	12 470	
3. Commercial Harvests							
1948-49	8 020	1 117	67	3 831	0	13 035	4
1949-50	18 041	2 443	629	9 505	0	30 618	14
1953-54	44 197	829	1 480	6 911	0	53 417	18
1954-55	57 240	2 321	1 554	5 011	0	66 126	26
1955-56	59 688	10 237	3 187	11 812	0	84 924	29
1956-57	57 865	9 782	6 471	10 111	5 600	89 829	28
1957-58	69 367	5 809	9 142	16 569	0	100 887	30
1958-59	77 557	1 058	7 682	15 653	0	101 950	27
1962-63	82 285	2 775	4 498	0	0	89 558	34
1963-64	76 255	11 795	4 654	179	0	92 883	66
1966-67	70 433	6 117	2 334	0	0	78 884	56
1967-68	74 520	16 175	4 910	1 179	0	96 784	29
Total	695 468	70 458	46 608	80 761	5 600	898 895	
Average	57 956	5 870	3 885	6 730	470	74 910	

Appendix 16. Commercial fish production (kg) from Montreal Lake, 1925-1988.

Year	Whitefish	Walleye	Pike	Other	Total	No. Licences
1925-26	3 042	363	1 090	636	5 131	2
1926-27	no fishing					
1927-28	5 085	2 497	4 086	7 264	18 932	58
1928-29	1 271	0	318	227	1 816	2
1929-30	no fishing					
1930-31	3 995	272	681	590	5 538	2
1931-32	4 722	908	953	2 588	9 171	2
1932-33	4 722	908	953	2 588	9 171	2
1933-34	5 111	100	59	1 180	6 450	2
1934-35	4 722	272	817	1 362	7 173	3
1935-36	11 350	681	454	1 317	13 802	5
1936-37	19 613	1 589	1 460	10 560	33 222	6
1937-38	22 079	1 419	570	5 580	29 648	8
1938-39	40 781	1 805	461	4 286	47 333	21
1939-40	54 344	863	1 271	4 313	60 791	16
1940-41	27 274	522	1 067	2 111	30 974	17
1941-42	25 463	1 403	1 154	7 260	35 280	15
1942-43	23 657	1 690	1 093	3 670	30 110	14
1943-44	16 117	2 236	999	2 043	21 395	17
1944-45	15 050	1 208	454	1 816	18 528	14
1945-46	no fishing					
1946-47	no fishing					
1947-48	no fishing					
1948-49	8 020	1 117	67	3 831	13 035	4
1949-50	18 041	2 443	629	9 505	30 618	14
1950-51	25 363	1 185	462	10 279	37 289	15
1951-52	40 199	599	685	15 132	56 615	19
1952-53	32 807	266	483	7 507	41 063	14
1953-54	44 197	829	1 480	6 911	53 417	18
1954-55	57 240	2 321	1 554	5 011	66 126	26
1955-56	59 688	10 237	3 187	11 812	84 924	29
1956-57	57 865	9 782	6 471	15 711	89 829	28
1957-58	69 367	5 809	9 142	16 569	100 887	30
1958-59	77 557	1 058	7 682	15 653	101 950	27
1959-60	86 467	344	4 939	9 205	100 955	29
1960-61	123 672	394	7 977	0	132 043	36
1961-62	106 419	1 864	6 402	232	114 917	35
1962-63	82 285	2 775	4 498	0	89 558	34
1963-64	76 255	11 795	4 654	179	92 883	66
1964-65	61 666	13 004	5 930	0	80 600	31
1965-66	68 745	26 680	7 513	0	102 938	48
1966-67	70 433	6 117	2 334	0	78 884	56
1967-68	74 520	16 175	4 910	1 179	96 784	29
1968-69	57 934	4 923	1 700	5 899	70 456	33
1969-70	71 609	9 443	4 368	0	85 420	31
1970-71	57 759	12 870	5 214	0	75 843	33
1971-72	65 240	16 235	4 296	0	85 771	33
1972-73	93 540	13 701	6 144	7 896	121 281	29
1973-74	48 743	23 391	2 609	1 456	76 199	30
1974-75	73 944	5 462	4 219	1 187	84 812	27

Appendix 16. Continued

Year	Whitefish	Walleye	Pike	Other	Total	No. Licences
1975-76	13 713	1 445	2 338	0	17 496	24
1976-77	69 451	10 121	2 433	0	82 005	30
1977-78	45 440	8 826	1 482	0	55 748	26
1978-79	25 695	2 899	1 264	749	30 607	18
1979-80	33 112	17 159	2 107	404	52 782	16
1980-81	22 927	35 293	1 727	3	59 950	24
1981-82	22 915	13 566	5 868	15	42 364	22
1982-83	42 147	4 601	8 082	1 398	56 268	25
1983-84	20 291	1 091	3 607	160	25 149	16
1984-85	6 327	793	1 053	0	8 173	9
1985-86	5 065	10 888	4 606	0	20 559	12
1986-87	5 450	8 987	8 304	228	22 969	12
1987-88	16 915	13 120	4 682	0	34 717	19
1988-89	16 285	23 990	4 621	0	44 896	20
Total	2 343 706	372 334	179 663	207 502	3 103 205	1 283
Average	36 620	6 311	3 045	3 517	52 597	
% of total	75.5	12.0	5.8	6.7	100.0	
kg/ha	0.82	0.14	0.07	0.08	1.18	